3-18

TRANSACTIONS

OF THE

Illinois State Academy of Science

EIGHTEENTH ANNUAL MEETING

SPRINGFIELD, ILLINOIS

February 20 and 21, 1925

VOLUME XVIII

Edited by C. F. Phipps, *Secretary*

(Printed by Authority of the State of Illinois)

Q11
I29
v.18

TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE.

A. R. Crook, *Librarian.*

State Museum, Springfield, Ill.

	PRICE.
Vol. I, 1908, paper binding. Published by the Academy.....	$1.50
Vol. II, 1909, paper binding. Published by the Academy.....	1.50
Vol. III, 1910, paper binding. Published by the Academy.....	1.50
Vol. IV, 1911, paper binding. Published by the State.....	Gratis
Vol. V, 1912, paper binding. Published by the State.....	Gratis
Vol. VI, 1913, paper binding. Published by the Academy.....	1.50
Vol. VII, 1914, paper binding. Published by the Academy....	1.50
Vol. VIII, 1915, paper binding. Published by the Academy....	1.50
Vol. IX, 1916, paper binding. Published by the Academy.....	1.50
Vol. X, 1917, paper binding. Published by the Academy.....	1.50
Vol. XI, 1918, paper binding. Published by the State.....	Gratis
Vol. XII, 1919, paper binding. Published by the State.....	Gratis
Vol. XIII, 1920, paper binding. Published by the State.....	Gratis
Vol. XIV, 1921, paper binding Published by the State.....	Gratis
Vol. XV, 1922, paper binding. Published by the State.....	Gratis
Vol. XVI, 1923, paper binding. Published by the State.....	Gratis
Vol. XVII, 1924, paper binding. Published by the State.....	Gratis

OHIO STATE UNIVERSITY

PHILLIPS BROS. PRINT.
SPRINGFIELD, ILLINOIS.

36663—1000
1925

TABLE OF CONTENTS.

PAGE

TRANSACTIONS ISSUED AND PRICES OF SAME 3

OFFICERS AND COMMITTEES FOR 1925-1926 6

PAST OFFICERS OF THE ILLINOIS STATE ACADEMY OF SCIENCE 7

MINUTES OF THE COUNCIL MEETINGS 11

MINUTES OF THE EIGHTEENTH ANNUAL MEETING, SPRINGFIELD 14

TREASURER'S REPORT 15

RESOLUTIONS PRESENTED AT THE SPRINGFIELD MEETING 17

ADDRESSES OF WELCOME, SPRINGFIELD MEETING 19

PAPERS PRESENTED AT THE GENERAL SESSIONS:

Science and the Treatment of Human Ailments. Dr. Walter G. Bain, St. John's Hospital, Springfield 29

The Science of Public Health—Actual and Potential Accomplishments. Thomas Parran, Jr., United States Public Health, Springfield 36

Attributes of the Human Organism. Dr. R. V. Brokaw, Sup't. of City Health Department, Springfield 48

Graphical Representation of the Theory and Practice of X-Rays. Charles T. Knipp, University of Illinois 58

The Mighty Amazon. W. H. Haas, Northwestern University .. 65

Some Problems of the Weather Man. Clarence J. Root, U. S. Weather Bureau, Springfield 69

Insect Hazard to Illinois Field Crops. W. P. Flint, Natural History Survey, Urbana 75

The Making of an Aerial Photographic Mosaic. Cap't Wm. D. Wheeler, Air Service Technical School, Rantoul 82

Some Wild Men of Borneo. John Stansfield, University of Illinois 97

PAPERS ON BIOLOGY AND AGRICULTURE:

Interesting Results from Bird-Banding Activities. Frank Smith, University of Illinois 107

Biological Characters and Biological Products. Casper L. Redfield, Chicago 113

Resistance of Earthworms to Soil Acidity. Mary M. Steagall, State Normal University, Carbondale 121

Lecture-Demonstration-Recitation-Technique in Biology Teaching. Jerome Isenbarger, Crane Junior College, Chicago ... 133

Notes on Nut Bearing Trees of Illinois. A. S. Colby, University of Illinois 138

Outstanding Features of the Plant Disease Situation in Illinois during 1924. L. R. Tehon, State Natural History Survey, Urbana 150

Lichens and Symbiosis. W. B. McDougall, University of Illinois 161

Phosphorus and the Early Maturity of Plants. Charles A. Shull, University of Chicago 165

The Significance of Fossil Footprints. L. A. Adams, University of Illinois 172

Notes on the Habits of Rhinoncus pyrrhopus Boh. W. V. Balduf, University of Illinois 178

Opportunities for Field Study in the Chicago Area. Hilary S. Jurica, St. Procopius College, Lisle 184

Past and Present Interest in Illinois Trees. R. B. Miller, Natural History Survey, Urbana 193

Three Alfalfa Diseases New to Illinois. L. R. Tehon, Natural History Survey, Urbana 203

The Fossil Flora of Northern Illinois. A. C. Noé, University of Chicago and Illinois State Geological Survey 206

334622

Some Interesting Southern Illinois Plants. G. H. French, Herrin, Illinois 208
Mistaken Notions of Scientific Phenomena as they now exist among Average Citizens. Clarence Bonnell, Township High School, Harrisburg..... 212
The Utilization of Farm Manure. H. J. Snider, University of Illinois 216
Contributions to the Flora of Hancock County, Illinois. Frank C. Gates, State Agricultural College, Manhattan, Kansas.. 225

PAPERS ON CHEMSTRY AND PHYSICS:

Chlorine for Colds. H. C. Kremers, University of Illinois.... 237
The Metric System for General Use. H. A. Neville. University of Illinois 245
Yard Sticks of Stream Pollution. R. E. Greenfield, Illinois State Water Survey 253
Some Problems of the Chemistry Teacher. G. M. Browne, State Normal University, Carbondale..... 259
Control of Successive Ionization by Collision in a Photo-electric Cell. J. Tykocinski-Tykociner, University of Illinois.... 262
Separation and Determination of the Alkali Metals, Using Perchloric Acid. I. The Solubility of the Perchlorates of the Alkali Metals in Mixed Organic Solvents. G. F. Smith, University of Illinois..... 268
Separation and Determination of the Alkali Metals, Using Perchloric Acid. II. The Precise Estimation of the Insoluble Alkali Metal Perchlorates. G. F. Smith and J. F. Ross, University of Illinois..... 277
Separation and Determination of the Alkali Metals, Using Perchloric Acid. III. Normal Butyl Alcohol and Ethyl Acetate as Mixed Solvents in the Separation and Determination of Potassium, Sodium and Lithium. G. F. Smith and J. F. Ross, University of Illinois..... 286
Tartaric Acid from Coal Tar Benzene. Ethel M. Terry, University of Chicago..... 295
Heat of Formation of Nitrogen Trichloride. (Abstract). W. A. Noyes and W. F. Tuley, University of Illinois..... 298
Asymmetric Dyes and the Mechanism of Dyeing. W. R. Brode and Roger Adams, University of Illinois..... 299
Further Improvements in the Formation of Alpha-Ray Tracks by Simple Means. Charles T. Knipp, University of Illinois 302
A Study of Colored Halites. T. E. Phipps and G. C. Mason, University of Illinois..... 304
Investigation of Antennae and of Radio Transmission by means of Models. J. Tykocinski-Tykociner, University of Illinois 309
The Preparation of Hydrogen Electrodes. Gerhard Dietrichson and C. N. Shar, University of Illinois..... 323
The Variation of the Declination during the Solar Eclipse of January 24, 1925, at Urbana, Illinois. Charles T. Knipp, University of Illinois..... 327

PAPERS ON GEOGRAPHY AND GEOLOGY:

The Panama Gateway as Related to the Intercontinental Trade of South America. W. O. Blanchard, University of Illinois 335
Will the Illinois Waterway Benefit the Illinois Coal Industry? Esther W. Utzig, University of Illinois..... 351
The Devonian Strata of the Alto Pass Quadrangle. Charles F. Bassett, University of Illinois..... 360
The Character and Significance of the Basal Conglomerate of the Pennsylvanian System in Southern Illinois. R. S. Poor, University of Illinois..... 369
Transition Beds Between the St. Peter Sandstone and the Platteville Limestone. Arthur Bevan, University of Illinois 376
Post-Chester, Pre-Pennsylvanian Faulting in the Alto Pass Area. G. E. Ekblaw, Illinois State Geological Survey.... 378
A Prolific Coal Field. Fred R. Jelliff, Galesburg..... 383

Some Features of Continental Glaciation. Terence T. Quirke, University of Illinois 394
The Farm Creek Exposure near Peoria, Illinois,—A Type Pleistocene Section. Morris M. Leighton, Illinois Geological Survey, Urbana 401
Comparison of the Devonian Rocks of Illinois and Missouri. T. E. Savage, University of Illinois 408
The oolite of the Ste. Genevieve Formation. J. E. Lamar, State Geological Survey, Urbana 409
Lantern Slide Examinations in Geology. F. P. Shepard, University of Illinois 414

PAPERS ON MEDICINE AND PUBLIC HEALTH:

Public Health Education in Retrospect. Baxter K. Richardson, Dep't of Public Health, Springfield 421
The Prevalence of Goiter in Illinois. Dr. J. Howard Beard, Health Service, University of Illinois 433
Impressions on English Sewage Disposal Practice. Paul Hansen, of Pearse, Greeley & Hansen, Chicago 441
A Demonstration on the Pollution of the Illinois River. R. E. Greenfield, Illinois State Water Survey Division 451
Reclaiming Apparently Hopeless Chest Cases. Dr. Don W. Deal, Dr. George T. Palmer and Dr. Hermon H. Cole, Springfield 453
Inertia Uteri (in a case of uterus bicornis) due to entire absence of Myometrium below the Fundus. Dr. Milton DeWitt Pollock, Decatur 460
The Results of the Application of Science in the Field of Medicine. Dr. T. Arthur Johnson, Rockford 465

PAPERS ON PSYCHOLOGY AND EDUCATION:

What can the Schools do in the Recognition and Treatment of Incipient Mental Disorders and Criminal Tendencies during School Age? Herman M. Adler, M. D., Director, The Illinois Institute for Juvenile Research, Criminologist of the State of Illinois 473
Foreign Language as an Entrance Requirement at Northwestern University College of Liberal Arts. R. A. Kent, Northwestern University 483
Phi Beta Kappa Students at Northwestern University,—What They Bring and What They Take. Wendell S. Brooks, Northwestern University 494
A Plan for Extra Institutional Care of Feebleminded Girls. Anna Polkowski, Lincoln State School and Colony 503
Relative Value of Different Types of Questions in Reading Tests. S. G. Brinkley, Illinois College 507
Variable Factors Encountered in the Rating of Students. Joseph V. Hanna, Personnel Director, Joliet Township High School and Junior College 515

PAPERS ON HIGH SCHOOL SCIENCE:

Science Clubs in the High School. Guy M. Smith, High School, Rockford 525
Making the Laboratory the Basis of High School Science. H. H. Radcliffe, High School, Decatur 530
The Relation of Mental Imagery to Mental Age. L. L. Hunt, High School, Galesburg 535
Bird Study in High School Biology. Jerome Isenbarger, Crane Junior College, Chicago 541
One Influence of Out-of-School Activities in Determining the High School Physics Curriculum. M. E. Herriott, University of Illinois 545

THE CONSTITUTION 553
THE BY-LAWS 554
LIST OF LIFE MEMBERS 559
LIST OF ANNUAL MEMBERS 559
SCIENTIFIC SOCIETIES AFFIIATED WITH THE ACADEMY 567
HIGH SCHOOL SCIENCE CLUBS 567

OFFICERS AND COMMITTEES FOR 1925-1926.

President, STUART WELLER, University of Chicago, Chicago.
1st Vice-President, MRS. ELEANOR C. SMITH, Englewood High School, Chicago.
2nd Vice-President, CLARENCE BONNELL, Township High School, Harrisburg.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, W. B. MCDOUGALL, University of Illinois, Urbana.
Librarian, A. R. CROOK, State Museum, Springfield.

The Council.

The Council is composed of the above officers and the last two retiring presidents.

Committee on Membership.

WM. M. BAILEY, State Normal University, Carbondale, Chairman.
R. S. POOR, University of Illinois, Urbana.
W. N. CLUTE, Editor of "American Botanist", Joliet.
THOS. G. HULL, Department of Public Health, Springfield.
MARY E. RENICH, 355 Jefferson St., Galesburg.

Committee on Affiliation.

W. S. BAYLEY, University of Illinois, Urbana, Chairman.
MRS. E. C. SMITH, Englewood High School, Chicago.
M. M. LEIGHTON, Chief, Geological Survey Division, Urbana.
W. G. WATERMAN, Northwestern University, Evanston.
C. A. SHULL, University of Chicago, Chicago.

Committee on Ecological Survey.

W. G. WATERMAN, Northwestern University, Evanston, Chairman.
GEORGE D. FULLER, University of Chicago, Chicago.
V. E. SHELFORD, University of Illinois, Urbana.
W. B. MCDOUGALL, University of Illinois, Urbana.
R. B. MILLER, State Natural History Survey, Urbana.
H. S. PEPOON, Lake View High School, Chicago.
RUTH MARSHALL, Rockford College, Rockford.
E. L. STOVER, State Teachers College, Charleston.
C. E. MONTGOMERY, State Teachers College, DeKalb.
CLARENCE BONNELL, Township High School, Harrisburg.
MARY M. STEAGALL, State Normal University, Carbondale.

Committee on High School Science and Clubs.

G. M. SMITH, Rockford High School, Rockford, Chairman.
J. A. CLEMENT, University of Illinois, Urbana.
E. R. DOWNING, University of Chicago, Chicago.
ALICE KIBBE, Carthage.
F. C. BOHANNAN, Galesburg High School, Galesburg.

Committee on Conservation.

H. C. COWLES, University of Chicago, Chicago, Chairman.
M. M. LEIGHTON, Chief, Geological Survey Division, Urbana.
W. N. CLUTE, Editor of "American Botanist", Joliet.
W. H. HAAS, Northwestern University, Evanston.

Committee on Legislation and Finance.

DON W. DEAL, Leland Office Building, Springfield, Chairman.
EDWARD W. PAYNE, First Trust & Savings Bank, Springfield.
CLARENCE BONNELL, Township High School, Harrisburg.
J. C. HESSLER, Knox College, Galesburg.
J. PAUL GOODE, University of Chicago, Chicago.

Committee on Publications.

THE PRESIDENT.
THE SECRETARY.
F. R. WATSON, University of Illinois, Urbana.

Delegate to the American Association for the Advancement of Science.
CHARLES T. KNIPP, University of Illinois, Urbana.

Delegates to the Conservation Council of Chicago.
STUART WELLER, University of Chicago, Chicago.
PAUL HANSEN, 6 North Michigan Ave., Chicago.

PAST OFFICERS OF ILLINOIS STATE ACADEMY OF SCIENCE.

1907

(Organization meeting, Dec. 7, 1907, Springfield.)

Chairman, U. S. GRANT, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.

1908

(First annual meeting, Decatur, Feb. 22, 23, 1908.)

President, T. C. CHAMBERLAIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1909

(Second annual meeting, Springfield, Feb. 20, 1909.)

President, T. C. CHAMBERLAIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1910

(Third annual meeting, Urbana, Feb. 18, 19, 1910.)

President, S. A. FORBES, University of Illinois.
Vice-President, JOHN M. COULTER, University of Chicago.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1911

(Fourth annual meeting, Chicago, Feb. 17, 18, 1911.)

President, JOHN M. COULTER, University of Chicago.
Vice-President, R. O. GRAHAM, Illinois Wesleyan University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1912

(Fifth annual meeting, Bloomington, Feb. 23, 24, 1912.)

President, W. A. NOYES, University of Illinois.
Vice-President, J. C. UDDEN, University of Texas.
Secretary, FRANK C. BAKER, Chicago Academy of Science.
Treasurer, J. C. HESSLER, James Millikin University.

1913

(Sixth annual meeting, Peoria, Feb. 21, 22, 1913.)

President, HENRY CREW, Northwestern University.
Vice-President, A. R. CROOK, State Museum, Springfield.
Secretary, OTIS W. CALDWELL, University of Chicago.
Treasurer, J. C. HESSLER, James Millikin University.

PAST OFFICERS OF THE ACADEMY—Continued

1914

(Seventh annual meeting, Evanston, Feb. 20, 21, 1914.)

President, FRANK W. DEWOLF, State Geological Survey, Urbana.
Vice-President, H. S. PEPOON, Lake View High School, Chicago.
Secretary, E. N. TRANSEAU, Eastern Illinois State Normal School, Charleston.
Treasurer, J. C. HESSLER, James Millikin University.

1915

(Eighth annual meeting, Springfield, Feb. 19, 20, 1915.)

President, A. R. CROOK, State Museum, Springfield.
Vice-President, U. S. GRANT, Northwestern University.
Secretary, E. N. TRANSEAU, Eastern Illinois State Normal School, Charleston.
Treasurer, J. C. HESSLER, James Millikin University.

1916

(Ninth annual meeting, Urbana, Feb. 18, 19, 1916.)

President, U. S. GRANT, Northwestern University.
Vice-President, E. W. WASHBURN, University of Illinois.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.

1917

(Tenth annual meeting, Galesburg, Feb. 23, 24, 1917.)

President, WILLIAM TRELEASE, University of Illinois.
Vice-President, H. E. GRIFFITH, Knox College, Galesburg.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.
Librarian, A. R. CROOK, State Museum, Springfield.

1918

(Eleventh Annual meeting, Joliet, Feb. 22, 23, 1918.)

President, J. C. HESSLER, James Millikin University.
Vice-President, JAMES H. FERRISS, Joliet.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, T. L. HANKINSON, State Normal School, Charleston.
Librarian, A. R. CROOK, State Museum, Springfield.

1919

(Twelfth annual meeting, Jacksonville, March 21, 22, 1919.)

President, R. D. SALISBURY, University of Chicago.
Vice-President, ISABEL S. SMITH, Illinois College, Jacksonville.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, T. L. HANKINSON, State Normal School, Charleston.
Librarian, A. R. CROOK, State Museum, Springfield.

1920

(Thirteenth annual meeting, Danville, Feb. 20, 21, 1920.)

President, HENRY B. WARD, University of Illinois.
Vice-President, GEO. D. FULLER, University of Chicago.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, W. G. WATERMAN, Northwestern University.
Librarian, A. R. CROOK, State Museum, Springfield.

PAST OFFICERS OF THE ACADEMY—Concluded

1921

(Fourteenth annual meeting, Carbondale, April 29, 30, 1921.)

President, HENRY C. COWLES, University of Chicago.
Vice-President, CHAS. T. KNIPP, University of Illinois.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, W. G. WATERMAN, Northwestern University.
Librarian, A. R. CROOK, State Museum, Springfield.

1922

(Fifteenth annual meeting, Rockford, April 27, 28, 29, 1922.)

President, CHAS. T. KNIPP, University of Illinois.
Vice-President, MISS RUTH MARSHALL, Rockford College, Rockford.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, WM. F. SCHULZ, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1923

(Sixteenth annual meeting, Galesburg, May 3, 4, 5, 1923.)

President, W. S. BAYLEY, University of Illinois.
Vice-President, W. G. WATERMAN, Northwestern University.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, WM. F. SCHULZ, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1924

(Seventeenth annual meeting, Elgin, May 1, 2, 3, 1924.)

President, W. G. WATERMAN, Northwestern University.
Vice-President, H. J. VANCLEAVE, University of Illinois.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb
Treasurer, WM. F. SCHULZ, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1925

(Eighteenth annual meeting, Springfield, Feb. 20, 21, 1925.)

President, DR. W. G. BAIN, St. John's Hospital, Springfield.
First Vice-President, C. H. SMITH, Hyde Park High School, Chicago.
Second Vice-President, R. C. LANPHIER, Sangamo Electric Co., Springfield.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, W. B. MCDOUGALL, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

ILLINOIS STATE ACADEMY OF SCIENCE

Office of the Secretary

State Teachers College, DeKalb, Illinois

Council Meeting, University Club, Chicago, June 7, 1924.

All the officers of the Academy, except the Librarian, were present. President W. G. Bain presided.

The following committees were appointed:

Committee on Ecological Survey—W. G. Waterman, Chairman; George D. Fuller, V. E. Shelford, W. B. McDougall, R. B. Miller, H. S. Pepoon, Ruth Marshall, A. O. Weese, M. M. Leighton, Clarence Bonnell, Mary Steagall. By vote the Chairman was given power to add names to this committee, subject to the approval of the President.

Committee on Conservation—H. C. Cowles, Chairman; M. M. Leighton, W. N. Clute. It was voted that the Council suggest to the Chairman that he enlarge this committee to five members, subject to approval of the President.

Committee on High School Science and Clubs—John A. Clement, Chairman; F. C. Bohannan, C. M. Turton. By vote the chairman was empowered to appoint two more members to this committee, subject to approval by the President.

After some discussion on the place of meeting for the 1925 Annual Meeting, it was voted that the Academy meet in Springfield. By vote the date of the next Annual Meeting was set for February 20th and 21st, 1925.

The Council authorized the President to appoint a committee of five,to be known as the Legislative and Finance Committee, the Chairman of this committee to be a Springfield member of the Academy.

In answer to a letter from Professor H. B. Ward, a member of the A. A. A. S. Council, relative to continuing the affiliation relationship between the Academy and the A. A. A. S., the Secretary was requested to reply that the Academy at this time cannot submit any arguments in

favor of any plan by which the Academy can aid the A. A. A. S. in a continuance of the affiliation plan.

By vote Dr. W. S. Bayley, University of Illinois, was elected the Academy delegate to the British Association of Science Convention to be held in Toronto August 6-13.

The request of the Carbondale Scientific Club for affiliation with the Academy was acted upon favorably.

After a discussion on the question of assisting the Membership Committee in securing new members, it was voted that the Council suggest to the Chairman of the committee that he ask Academy members in different localities to speak before societies, groups of teachers, etc., and explain the aims and work of the Academy and the advantages of becoming a member.

By vote Robert Lanphier, Springfield, was elected 2nd Vice President of the Academy and Chairman of the Local Committee on 1925 Annual Meeting.

Moved and carried that the President appoint two delegates to represent the Academy on the Conservation Council of Chicago. The President appointed H. C. Cowles and W. G. Waterman.

The Treasurer presented six names to be passed on for membership. It was voted to present these names at the next meeting of the Academy.

The President appointed the following Chairmen of Section Meetings for the Springfield Meeting—T. H. Frison, Urbana, Biology and Agriculture; Albert Noyes, Jr., Chicago, Chemistry and Physics; F. H. Colyer, Carbondale, Geography and Geology; A. M. Buswell, Urbana, Medicine and Public Health; H. A. Peterson, Normal, Psychology and Education.

W. G. Waterman was authorized to have more leaflets printed, if the type was still set up, presenting the aims and work of the Academy.

Meeting adjourned.

Council Meeting at Urbana, November 22, 1924

Present—The President, First Vice-Presiden', Treasurer, Librarian and Past President Bayley.

Brief progress reports were made by Chairman Bayley for the Committee on Affiliation and by President

Bain for Chairman Richardson for the Committee on Membership.

The Local Committee for the Springfield meeting was announced as follows: Robert C. Lanphier, Chairman; Aubrey Cribb, Clarence W. East, E. E. Hagler, Edward W. Payne, Baxter K. Richardson, Clarence J. Root.

The Treasurer presented two names for membership. These were approved. The Treasurer presented the following preliminary report:

Balance May 1, 1924	$ 312.53
Receipts May 2 to Nov. 21, 1924	483.60
	$ 796.13
Expenditures May 2 to Nov. 21, '24	495.05
Balance November 21, 1924	$ 301.08

The work of the Legislative Committee was discussed. It was the opinion of the Council that the greatest need is increased funds for publication and that the Chairman of the Legislative Committee should be asked to consult with the Librarian concerning this need. No vote was taken.

It was voted to instruct the Secretary to communicate at once with the Chairman of the Committee on Conservation urging him to find some way, if it is at all possible, to save a small piece of forest near Urbana known as the Brownfield Woods. The estate owning these woods is to be settled soon and the woods sold at auction; therefore prompt action is imperative. These are the *only* woods available for the use of the University community, and the proposition to save them from destruction is of vital concern to the entire state because of the fact that the 9000 students at the University come from all parts of the state.

A letter from Prof. H. B. Ward concerning the affiliation of the Academy with A. A. A. S. was discussed at some length. Professor Ward was present during the latter part of this discussion. By vote the Treasurer was instructed to prepare a statement setting forth the views of the Council as brought out during this discussion, this statement to be sent to Professor Ward after being submitted to the President for approval.

The program for the Springfield meeting (February 20 and 21, 1925) was discussed. It was tentatively agreed

to have a business meeting and the President's address Friday morning, a general session Friday afternoon, a dinner followed by a general session with invited speakers Friday evening, section meetings Saturday morning, and some special features such as clinics, inspection of hospitals, etc., Saturday afternoon. The details of the program were left to the President with such help as he may need from the Secretary and the local Committee.

The meeting adjourned.

W. B. McDougall,
Secretary, Pro tem.

Annual Meeting, Springfield, Illinois
February 20 and 21, 1925

Council Meeting, February 20.

The Council was called to order by President Bain at 8:30 A. M. in the office of the State Museum. The Springfield Local Committee of Arrangements was represented by Dr. Bain and Dr. Crook. The latter reported that all arrangements for the Annual Meeting had been completed and that special invitations to attend had been sent to the State Legislators and to many prominent citizens of Springfield.

The Secretary read a letter from Professor C. T. Knipp which stated that he had represented our Academy at the Council Meeting of the American Association for the Advancement of Science held in Washington last December. He reported that no action was to be taken by the A. A. A. S. before October 1, 1925 on the matter of the present affiliation of the State Academies.

Professor McDougall, the Treasurer, read a list of names for membership in the Academy. It was voted that the Council approve the names and present them at the annual business meeting for election.

Professor Bayley, Chairman of Committee on Affiliation, reported the following scientific societies for affiliation with the Academy: The Botany Club of Joliet; the Englewood Botany Club; Sigma Xi, the University

of Illinois Chapter; Sigma Xi, the University of Chicago Chapter; the Chicago Academy of Science; the Joliet Biological Club; and the Burrill Botany Club of Urbana. The council voted to approve these affiliations.

The President reported that A. M. Buswell, Chairman of Medicine and Public Health Section, would be unable to attend the Annual Meeting. It was voted that Dr. J. H. Beard be appointed Chairman in Mr. Buswell's place.

It was voted that Capt. William D. Wheeler, scheduled to give an address Friday evening, should have his travelling expenses paid from Rantoul, Illinois.

By vote two members, who were elected a year ago but had paid no initiation fee or dues, were dropped from the Academy roll.

Annual Business Meeting, Friday, February 20, 1925

The meeting was called to order at 9:15 A. M. by President Bain. Reports of officers and committees were colled for.

The Treasurer submitted the following report for the last year:

RECEIPTS.

Balance on hand May 1st, 1924	$ 312.53	
Local dues collected	221.00	
National dues received	240.00	
Received from sale of Transactions	43.50	
Received for reprints from authors of papers, Vol. 17, Transactions	214.10	
Received for part of cuts in Transactions	3.44	
Total Receipts		$ 1,034.57

DISBURSEMENTS.

Printer's bill, reprints from Vol. 17, Transactions	$ 197.09	
Refund of excess dues	2.00	
Expenses of Treasurer's Office	37.65	
Expenses of Secretary's Office	296.40	
Expenses of Council Members	25.90	
Expenses of Committee on High School Science and Clubs	2.84	
Secretary's Salary	150.00	
Total Disbursements		711.88
Balance on hand Feb. 19, 1925		$ 322.69

The Secretary reported that the Transactions for the Elgin Meeting had been received, and had been sent out from the Office of the Librarian, Dr. Crook, on February 17th.

The Chairman of the Membership Committee, Baxter K. Richardson, submitted a splendid list of 54 new members to be voted in. One was a $20 life membership. They were all elected to membership. This Committee deserves much credit for its good work.

Professor Bayley, Chairman of the Affiliation Committee, submitted for affiliation the eight scientific societies which were approved by the Council. Voted to accept the affiliation of these societies. With the five societies previously affiliated, the total is now thirteen. Each affiliated society is privileged to send a delegate to meet with the Council at the Annual Meeting of the Academy.

Dr. H. C. Cowles, Chairman of the Committee on Conservation, reported that two important bills have been introduced in the State Legislature,—one favoring a State Park law, and the other favoring a State Forest law. Both stand a good show of being helped by the present administration. Dr. Cowles urged all Academy members to write their State Representatives to work for the passage of these bills.

The Chairmen of the Committees on Ecological Survey, High School Science and Clubs, and Legislation and Finance were absent, and no reports were sent in.

The President appointed the following committees, to report at the afternoon business meeting:

Committee on Nominations—Charles T. Knipp, Chairman; Clarence Bonnell, C. M. Turton, W. S. Bayley and Mrs. Eleanor Smith.

Committee on Resolutions—John C. Hessler, Chairman; Mary M. Steagall and T. H. Frison.

Committee on Auditing—C. A. Shull, F. H. Colyer and L. E. Hildebrand.

Meeting adjourned to meet at 5:15 P. M.

Business Meeting, February 20, 5:15 P. M.

President Bain presided. Reports of Committees called for. C. A. Shull reported for the Auditing Committee that the books of the Treasurer had been examined and found correct. Report accepted.

J. C. Hessler, Chairman of the Committee on Resolutions, handed in a written report as follows:

Report of the Committee on Resolutions

Your Committee on Resolutions desires to report as follows:

Resolved that the Illinois State Academy of Science records its sorrow at the death of two of its members: Mr. C. M. Wirick, a member of many years' standing, and instructor of Chemistry in the Crane Technical High School and Junior College, Chicago; and Dr. George M. Kreider, one of the leading surgeons of the state.

Resolved that the Illinois State Academy of Science expresses its thanks and appreciation to all the persons and local organizations that, by their kindness and hospitality have made the Annual Meeting of February 20 and 21, 1925, a successful and profitable one;

That the Academy is especially grateful to the Committee on Arrangements, Mr. R. C. Lanphier, Chairman; to Dr. A. R. Crook on the Staff of the Illinois State Museum; to the Springfield Chamber of Commerce; to Mr. Aubrey Cribb, Manager, Illinois Bureau Associated Press; to the local press of Springfield; to the Board of Education and the Superintendent of the Springfield Schools; to the Mayor of the city; to the Department of Registration and Education of the State of Illinois; to the Departments and Laboratories of Public Health, State Highways, and St. John's Hospital; and to the ladies of Springfield who assisted in providing the luncheon; and we suggest that copies of these resolutions be sent by the Secretary of the Academy to the persons and organizations concerned.

Resolved, finally, by the Illinois State Academy of Science: (1) That we endorse the proposed establishment of a Department of Conservation; (2) that we agree to render both moral and material support to the creation of such a department; and (3) that we support the passage of bills, by the Legislature of the State, for the conservation of forests, of wild life, of pure water courses, and of all other natural resources in the State of Illinois.

Respectfully submitted,

JOHN C. HESSLER,
THEODORE H. FRISON,
MARY M. STEAGALL,
Committee.

Charles T. Knipp, Chairman of Nomination Committee, submitted the following names for officers and committees of the Academy:

President, Dr. Stuart Weller, University of Chicago; First Vice-President, Mrs Eleanor C. Smith, Englewood High School, Chicago; Secretary, Professor C. Frank Phipps, State Teachers College, DeKalb; Treasurer, Dr. W. B. McDougall, University of Illinois; Librarian, Dr. A. R. Crook, State Museum, Springfield.

By vote the Secretary was empowered to cast the ballot of the meeting for the above officers. They were declared elected.

Nominations for Membership Committee

Wm. M. Bailey, State Normal University, Carbondale, Chairman.

R. S. Poor, University of Illinois.

W. N. Clute, Editor "The American Botanist," Joliet.

Thomas G. Hull, State Board of Health, Springfield.

Mary E. Renich, Knox College, Galesburg.

Nominations for Committee on Affiliation

W. S. Bayley, University of Illinois, Chairman.

Mrs. Eleanor C. Smith, Englewood High School, Chicago.

M. M. Leighton, Chief, Geological Survey Division, Urbana.

W. G. Waterman, Northwestern University.

C. A. Shull, University of Chicago.

Nomination for third member to serve on Publications Committee with the President and the Secretary—F. R. Watson, University of Illinois.

The Secretary was instructed to cast the vote of the Academy for the above committeemen. They were declared elected.

An opportunity was given for any invitations for the Annual Meeting of the Academy in 1926. Clarence Bonnell extended an invitation for the Academy to meet in Harrisburg. The next meeting place will be decided upon later by the Council.

The Treasurer presented one more name for membership. By vote the candidate was elected.

Meeting adjourned.

The luncheon and the dinner on Friday and the dinner Saturday noon afforded enjoyable opportunities for social hours. The members appreciated the generosity of the Local Committee and the ladies of Springfield in providing the splendid complimentary meals on Friday. The meeting with the Mid-Day Club for dinner Saturday, followed by President Burton's address, were additional treats.

During Saturday afternoon automobiles were furnished by Springfield friends, and Academy members were taken to various places of interest, among them being a trip to a coal mine, a visit to Lincoln's Tomb, and visits to the Laboratories of the State Department of Health, the State Highway Department and St. John's Hospital. These trips concluded a most profitable and enjoyable two day meeting of the Academy.

The Academy feels exceedingly grateful to the Local Committee and to the citizens of Springfield who helped in any way to make the 1925 Annual Meeting a decided success.

C. Frank Phipps,
Secretary.

Addresses of Welcome

A. M. Shelton, Director Department of Registration and Education, Springfield
(Representing Governor Len Small)

Members of the Illinois Academy of Science:

Due to the insistent and endless pressure of public duty, Governor Small is unable this morning to extend to you in person his hearty welcome and cordial greeting. His inability to be present to attend the session of your meeting is to be regretted because he is deeply interested in the various fields of education. During the first term of his office just closed, he recommended and approved from State sources of income gigantic increases to education, aggregating more than twenty-four and a half million dollars.

Governor Small has directed me to welcome you in his behalf and to say to you, if possible, a word of encourage-

ment and to wish you Godspeed in your noble and purposeful work.

The names of distinguished scholars make up the roster of your membership. Your object is to promote scientific research and to diffuse scientific knowledge. Here you are met, in a friendly spirit of co-operation. Here, constructive criticisms are made and new ideas exchanged. How different from the streets and every day life! There one loose view is as good as another and everything is usually stated but little is proved. To understand the intricate forces of nature, however, and to make accurate deductions therefrom involves knowledge far beyond the reach of ordinary minds.

You would determine the laws of nature, their character and influence to the end that we may live in harmony with them. You would advance our standards of living through a better understanding of the laws of nature and of human nature.

The people must have faith and must continue to look to just such groups as this for guidance, stability and confidence. Throughout this broad land of ours are similar groups of thoughtful men and women, well equipped for their specific work and, like you, they have wrought mightily in the making of America. It is for you and your kind to lead and for us, as laymen, to follow.

Again, in behalf of our Governor, Honorable Len Small, I bid you a hearty greeting.

Hon. Samuel Bullard, Mayor of Springfield

We are glad to welcome you to our city on this occasion. We like at any time to meet well intentioned, earnest minded people devoted to attaining certain high standards in any of the affairs of life, and on this opening session of your annual meeting I am doubly glad to give you welcome.

When you go visiting, your hosts like to show off. The children bring out their dolls, skates and scooters; the young man shows the family automobile; the girl, the linen, cut glass, and silverware; the man, his house and grounds, the pride of his life; and the woman, the pictures and heirlooms. And you are expected to admire

and compliment until all are happy. So we come to you today and tell you we want you to see our city, its parks, trees, buildings, treasures of art and science, schools, churches, hotels, homes, business houses, and our wonderful memorials of events, scenes and former men and women of our city, a sacred trust which we hold ourselves responsible to maintain for those who come after us. So we invite you to see and note all of these.

I am reminded of a notable philosopher and scientist of a century ago who once said, "The undevout astronomer is mad." I feel it might be more certainly said today that the undevout scientist is a madman.

The study of science ought to be followed with head uncovered and upon the knees. Whether you with a knife cut a graft, or with a hammer break a rock, or with a net capture a butterfly or with a telescope count the stars or with a microscope classify the microbes, you are uncovering what God has remotely or recently done. If you are seeking truth with your heart as well as with your brain, you will often find spots where God has just lifted His hand and which are yet warm from the touch of His fingers. And if your moral acumen is as true as your heart throbs, you will hear, as did the great seeker after God's plan on Mount Horeb ages ago, "The ground whereon thou standest is holy ground." Some months ago I had the profound pleasure of visiting Yellowstone Park and the Grand Canyon of the Colorado. In the latter we could see what God in ages gone by had wrought. There were domes and towers, castles and temples, minarets and spires of a puzzling vastness and intricacy, calling forth from the mind a feeling of wonder at the infinite detail of all this work. The vast canyon, more than a mile in depth, was a striking example of what God has done. While in the Yellowstone, the seething and steaming of fissures, holes and streams, and the rumble of thunder mountains and bubbling of firestone river startle one with the question of what God is going to do next. Surely by listening, one can plainly hear the injunction, "Remove the shoes from off thy feet." But you have long recognized all this. I do not hope to give you anything new; I hope only to remind you of what you have already noticed.

Again I take pleasure in welcoming you to our city, and in part your city, inasmuch as this is also the Capital of the State, hoping that your stay with us may be so pleasant and profitable that you may be pleased to return here at some other time for another annual meeting.

J. Harry Winstrom, Superintendent of Schools, Springfield

As a representative of the public school system of Springfield it affords me much pleasure to welcome the members of the Illinois State Academy of Science to our city in this annual meeting. When I extend this greeting, I speak not only for teachers and administrators but for the patrons and pupils of our schools as well because it is the latter for whom our public school system is founded.

You may feel oftentimes that the public generally is not appreciative of scientific progress and advancement. May I suggest that there has been a decided change in this respect during the last few years? It is not so long ago that a parent was fearful of sending a child to school because of the danger of becoming infected with some contagious disease. The danger is there yet, but not in the degree that it was before men and women representing your professions and your organization began making scientific investigations and experiments for the purpose of controlling disease. You men and women engaged in scientific research, working as you do in laboratories in which the general public apparently has no interest, need to bear in mind that there are many mothers and fathers who appreciate deeply what you have done and are doing to make living conditions more safe, pleasant and comfortable.

Not only has science contributed much toward safeguarding the health of our children, but also in protecting our pupils against the danger of extreme weather conditions. With the aid of the telephone, telegraph and the radio, the people who live in the remotest districts have warning of impending storm. The blizzards of some years ago, which claimed as victims not only children but teachers as well, no longer are a menace. The modern

weather bureau and our means of communications prevent a recurrence of such tragedies. In our city schools this same service is extended, and as a result proper steps are taken to meet the emergencies of weather conditions with the least possible expense and discomforture.

I have named these examples for the purpose of emphasizing the thought that you men and women engaged in scientific research of one kind or other are making very important contributions toward providing safe and pleasant conditions in our schools. There is more general appreciation of this service than you realize. You are to be congratulated in your achievements and given assurance that teachers, patrons and pupils wish you well in your future endeavor.

A. R. Crook, Chief, State Museum, Springfield.

It is now nearly eighteen years since the State Academy was started in Springfield under the auspices of the Museum, and in the name of the Museum we are glad to greet you here today.

During these eighteen years science has made remarkable progress. So rapidly have discoveries been made and new knowledge gained that we are unable to keep pace with them. They fade from our view as do the telegraph poles which disappear in the distance to the passenger on a rushing train. We take these advances as a matter of course and forget them almost as soon as they are past.

Who can recall even the most notable discoveries which have been made in the last eighteen years? Even those of last year are apt to be forgotten by this time. Do we remember the progress made in chemistry and physics, in geology, in biology? Do we remember that in 1924 astronomers added not only new planets or new suns but even new universes to the cosmos? We already had enough universes for all practical purposes, and yet with prodigal liberality astronomers have given us new universes. With the matter of time they have been even more generous than heretofore, although we never

did complain of their nigardliness in the matter of years. They have allowed us thirty trillion years as the length of life of certain of the stars.

During the year just past for the first time pictures have been transmitted by radio and other things in this line marvelous to contemplate have happened. Men have made new conquests of the air, circumnavigating the world as fliers, and have passed from one end of our country to the other in the Pullman-like luxury of a Zeppelin.

It is especially appropriate at this time to emphasize medicine in our Annual Meeting, since during the year just passed medicine has made many notable advancements. Scarlet fever has been conquered. A new knowledge of the value of ultra-violet rays has made possible better health. Vitamines have been for the first time isolated. Discoveries of this kind will contribute greatly to the health of mankind.

As in science, pure and applied, great progress has been made, and the State Academy has a part in this progress, so also we are glad to say that the Museum has made real progress. The museum is now housed in attractive quarters, the collections have been greatly increased, and the institution bids fair to be one of which the members of this Academy and citizens generally may be proud.

The Academy has always been helpful to the Museum. Five members of our Board are members of the Academy. Many members have striven in various ways to promote the interests of the Museum. The Academy as an institution has at various times taken action tending to increase the effectiveness of the Museum. For this relationship we are very grateful, and we hope that as in each succeeding year the younger members take the place of the older men of strength in our company, the younger members too may keep a watchful eye upon this institution and be always ready to lend their influence to the end that good work may be done here.

The name of our county—Sangamon—means "a place where there is plenty to eat." We hope you will find

this to be the truth. The name of this State Museum should mean "a place where there is plenty to see." The name State Academy means an organization where there is plenty to hear and think about. With such a setting and with such conditions I trust that our meeting may prove to be one of great pleasure and profit to us all.

PAPERS PRESENTED AT THE GENERAL SESSIONS OF THE SPRINGFIELD MEETING

SCIENCE AND THE TREATMENT OF HUMAN AILMENTS

WALTER G. BAIN, ST. JOHN'S HOSPITAL,
SPRINGFIELD, ILLINOIS

In nature, disease and accident give rise to pathologic conditions, or variations from the normal, which are constantly occurring. Any observer of biologic activities must be impressed with the tendency of nature to restore to the normal, variations from the usual growth and development, no matter by what accident or disease these variations have been brought about. In other words, the natural progress of disease, whether occurring in plants, animals, or human beings, is toward recovery. A disease in a human being is known as a human ailment.

The importance of the law of natural progress toward recovery, when applied to the treatment of human ailments, can, with abundant evidence, be easily proven, since of the ailments of sufficiently incapacitating degree to cause a person to consult one who sets himself up to treat such ailments, eighty-five per cent would progress naturally toward complete recovery. That is, even though the sufferers never sought treatment, eighty-five per cent of these ailments would adjust themselves.

There is nothing in the history of the human race to lead us to believe that the percentage of self-adjusting human ailments was ever less in the past than it is in the present. I lay emphasis on this fact at this point in my discussion of science and its relation to human aliments, so that you may continue to bear in mind the fact that whoever, at any time in human history, has set himself up to treat human ailments always was assured of eighty-five per cent of success, unless the treatment applied was in itself fatal.

Mythology teaches that before the dawn of history, man contended with human ailments, and also that there were those who professed the ability to treat those ailments.

The early history of disease and its treatment was a period of mysticism, when treatment for prevention and cure consisted of charms and incantations, ad-

ministered as religious ceremonies. Even yet, among the uncivilized this same attitude toward human ailments prevails, and to some extent it still permeates civilized peoples.

The period of mysticism in the treatment of human ailments was followed by a period of theory, when various explanations were offered as the cause of disease. Hippocrates explained disease by the Humoural Theory, according to which the body contained four Humours; blood, phlegma, yellow bile, and black bile, the right proportion and mixture of which constituted health. Another explanation was the Atom Theory of Asclepiades, wherein all diseases depended upon alterations in the size, number, and movement of the atoms of which the body was made up, the proscribed treatment being athletic training.

The third period was one of isolated facts, when those concerned with the treatment of disease began to observe and record for the world, facts relative to human ailments. Outstanding among these records was Paracelsus, whose records include reports on the therapeutic value of a number of metallic and vegetable preparations, including tincture of opium to which he gave the name of laudanum. Another outstanding recorder was William Harvey, who discovered the circulation of the blood.

Other important records continued to accumulate in the fields of chemistry and the other natural sciences, until the time of Darwin, Virchow, and Pasteur, which marks the beginning of a fourth period. This was a period of deducing laws from isolated facts, discoveries, and observations. It was the laws formulated by these men and their contemporaries which constitutes the basis of scientific treatment of human ailments.

Science may be defined as the orderly knowledge of natural phenomena. Medicine may be defined as the theory of the causation of disease, and the science of medicine, as we understand it, has for its province the treatment of disease, or the treatment of human ailments. Since this beginning in the classification of the knowledge of natural phenomena, there has been scarcely a discovery in physics, chemistry, biology, bacteriology,

physiology, or anatomy, that has not been of value in developing the fundamental laws of disease and its treatment.

"The science of medicine does not know the name of any school which restricts the activities of investigation."

"The introduction of scientific methods into medicine has shown that in practically every so-called 'School of Medicine' there is a kernel of truth which may be valuable to the physician, ... but which truth, when used beyond its natural limit of application, is reduced to an absurdity. All that is good in all the schools or all the creeds belongs to the school of medicine."

Any school of medicine worthy of the name must recognize the anatomical systems of the body, as they occur embryologically; must recognize the relation of disease to cellular toxins from which develop the principles of sepsis and immunity; must recognize the relation of health to the chemistry of cell metabolism and the multiple stimuli, both physical and chemical, organic and inorganic, which influence cell metabolism. Once these laws have been accepted, understood, and acknowledged, the multitude of facts related to human ailments and their treatment becomes immensely simplified. The person who thus hopes to claim proficiency in the treatment of human ailments has laid a foundation for the utilization of all scientific knowledge in the practice of his profession.

The man in general practice, or the family physician, is the one who, above all others, should be schooled in the general sciences, for he must first meet the emergency of sickness and accident. He must decide the seriousness and character of the ailment, and he must decide on the general course of treatment. On him the sick one must depend for advice as to whether or not his illness needs the skill of one trained in a specialty. If the man in general practice does not have the necessary training in science, and for lack of it fails to recognize the seriousness of the condition about which he is consulted, the sick one may, when it is too late, discover that his health has been entrusted to one who is incompetent, and who is unworthy of the trust accorded one who claims knowledge of how to treat human ailments.

When one wishes to confine his activities to a special branch of medicine, he is only justified in so doing after he has received a sufficiently comprehensive education in all branches of science to train him in the classification of the numerous discoveries which the advancing sciences are producing. For, if the specialist fails to recognize and utilize all scientific knowledge related to his specialty, his position becomes one of questionable stability in the scientific world.

The present tendency marks not only a period of specialization in medicine, but a specialization based upon all related scientific knowledge applied to a limited field. In general, the recognized special fields of medical science are: Internal Medicine; Surgery; Treatment of the Organs of Special Sense; Dentistry; and Preventive Medicine.

The man who undertakes to specialize in Internal Medicine must have received his training in the natural sciences; must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, he must become particularly familiar with the more important principles of physiology, chemistry, and biology, as they have to do with cell metabolism and nutrition. He must also be a constant student of pathology and physiology and botany as it relates to pharmacology.

The man who undertakes to specialize in Surgery must have received his training in the natural sciences; must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, he must become particularly familiar with anatomy and many important mechanical principles of physics.

The man who undertakes to limit his work to the treatment of Diseases of the Special Senses must have received his training in the natural sciences; must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, he must have an intimate knowledge of the minute

anatomy of the organs of special sense, and the principles of physics by which they function.

The man who undertakes to specialize in Dentistry must have received his training in the natural sciences; must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, and his mechanical skill, he must have an intimate knowledge of the anatomy of the head, and of bacteriology.

The man who undertakes to specialize in Preventive Medicine must have received his training in the natural sciences; must have familiarized himself with the ordered laws of medical science; must have been schooled in deducing from these laws the general indications for treatment. In addition to this, he must be a constant student of chemistry, bacteriology, and physics.

Unless the specialist has established in his own mind the relation of his specialty to all the fundamental principles of disease and its treatment, he will not be able to recognize the nature of serious pathology when it presents itself.

When a man sets himself up as proficient in the treatment of disease from the standpoint of a specialist, he must possess familiarity with the natural sciences and the previously mentioned classified studies of scientific medicine. He must possess an attitude of mind which makes him honestly desire a maximum of efficiency in a limited field, for which he will receive compensation in proportion to the art with which he applies this specially acquired knowledge. If he does not possess this broad foundation of the knowledge of the natural science; if he is not familiar with the ordered laws of medicine; if he yet holds himself up as a specialist in some department of the treatment of human ailments, then he is not honestly endeavoring to advance the knowledge of disease and its treatment. For treatment, uninspired by scientific understanding of the etiology, or origin and character of the disease in question, is nothing more than an experiment. It is neither necessary nor ethical to experiment on human beings.

The man who so experiments is taking advantage of the public belief in the specialist for the one and sole purpose of collecting money from that eighty-five per cent of demands made on him for advice in pathological cases and conditions which are naturally self-adjusting. A man with such lack of scruple usually possesses sufficient knowledge of disease to differentiate a part, at least, of the cases which require special scientific knowledge for their cure, and he does not attempt to treat cases which require a high degree of skill. His art consists in a diplomacy in ridding himself of those sick who require surgical treatment, who can be benefited only by the application of a high degree of medical care, or those who would certainly die in spite of any treatment. His education consists rather in studying the patient to determine how he can continue to collect for the given attentions, and how best he can conceal the situation from his patient. As a rule, the person best fitted for diagnosis and treatment of human ailments promises the least in the way of cure, whereas he who is the least equipped to diagnosis and treat promises the most.

So much for the present-day relation of science to the treatment of human ailments, which we have designated as the Period of Specialization. From the present tendency one can prophesy that the future will tend toward an even greater specialization. The future promises to make many new facts available to the physician through the researches in physics and chemistry, particularly colloidal and physical chemistry.

The future science of medicine depends for its progress upon the researches of investigators in the natural sciences, and the future art of medicine depends upon the skill with which the physician adopts these discoveries in the prevention and treatment of human ailments. It is this dependence of medical science for its advance by way of researches in the natural sciences that makes it necessary for you who are carrying on these researches to be ever watchful to guide into the study of medicine those who are by education and temperament best fitted to put to practical use these relations of science to medicine.

Thus, when comes to your attention a young man who is a lover of nature; who takes much interest in his studies of physics, chemistry, and biology; who has a natural inclination to mechanics; and who shows more than ordinary powers of deductive reasoning, advise that young man to take up the study of medicine. If he lacks any one of these three qualities, he will not succeed from the standpoint of one who advances the science of medicine, and one who is to be trusted with the treatment of human ailments. Lacking one or more of these qualifications, but possessing a fair knowledge of human psychology, he may succeed, of course, from a financial standpoint.

The responsibility, then, for the future of the medical profession rests as much with the teachers and research workers of the natural sciences as with the medical profession itself.

REFERENCES.

"Modern Progress in Medicine"—Sir Thomas Clifford Alburt.
"History of Medicine."—Alexander Wilder, 1901.
"History of Medicine."—Encyclopedia Brittanica, XIth Ed.
"History of Medicine."—Walter Libby.
"The Services of The Sciences to Rational Medicine."—Harvey W. Wiley, N. Y. State Jr. of Medicine, April 16, 1912.
"The Relation between Chemistry and Medicine."—Prof. F. Francis, Bristol Medico-Chirurgical Journal.
"Hand-book for the Medical Research Laboratory and The Research Ward."—Sir Almroth E. Wright.
"The Relation of Medicine to the Ancillary Sciences."—Samuel West, London Lancet, Oct. 16, 1909.
"The Future Independence and Progress of American Medicine." A Report by:
John J. Abel,
Carl D. Alsberg,
Raymond F. Bacon,
F. R. Eldred,
Reid Hunt,
Treat B. Johnson,
Julius Stieglitz,
F. O. Taylor,
Chas. H. Herty.

THE SCIENCE OF PUBLIC HEALTH

ACTUAL AND POTENTIAL ACCOMPLISHMENTS

THOMAS PARRAN, JR., UNITED STATES PUBLIC HEALTH SERVICE, SPRINGFIELD

The title of this paper may be somewhat misleading, in that public health in itself is not a science in the sense that physics, chemistry and zoology are sciences. It has been defined as a science and as an art, but a clearer conception seems to me to be that public health in the abstract is a relative state of being, and that as a profession it exists not as a distinct science, but levies tribute from all the sciences, gathering to itself knowledge from many sources and applying this knowledge for the conservation of our vital assets. If public health were considered merely as a branch of medicine it would be difficult to measure its accomplishments. Every branch of science has contributed its share towards improvement of the common weal, but who can measure exactly the contribution of each? Considering public health, however, as a field of activity created by a levy upon the best knowledge of all the sciences, an appraisal of its accomplishments becomes more simple, and credit for them spreads over the whole field of science. It is in this spirit that I approach the subject.

ACCOMPLISHMENTS DURING THE PRESENT CENTURY

For the sake of simplicity I will limit my discussion of public health accomplishments to the present century, since it is here that the most rapid strides have been made in human conservation and since statistical records, even now by no means complete, are more comparable since 1900. The last quarter of the 19th century saw the foundations laid upon which modern public health has been builded, but in its practical application, until recent years, it has been more of a promise than a fulfillment. Even now there is a gross disparity between the science and the practice of public health. There is too great a lag between the acquisition of scientific facts concerning the prevention of disease and their practical application by and for the mass of the people.

Between 1900 and 1923 the average span of human life in the United States has increased from 49 to nearly 57 years—eight years added to the life span.

Deaths of infants under one year of age per 1,000 live births have decreased from 160 in 1900 to 71 in 1923.

Typhoid fever has decreased from 31.3 to 6.8.

The death rate from tuberculosis has been more than halved during the same period.

Without going into detailed figures for all of the preventable diseases which are shown in Table I, suffice it to say that if the death rate which existed in this country at the beginning of the century now prevailed, five hundred thousand additional deaths would occur each year. Although the improved mortality experience has been most marked in the younger years of life, it has not taken place at the expense of the older age-groups. Between 1910 and 1920, for instance, the life expectancy improved in every decade of life.

TABLE NO. I.

Mortality rates in Illinois for the year 1923 from certain specific causes in Chicago; and in the rest of the State.

	Chicago	"Down-State"
*General Death Rate (per 1,000)	11.7	12.3
Typhoid Fever	1.2	6.6
Scarlet Fever	2.9	3.6
Measles	7.2	9.1
Whooping Cough	4.8	9.6
Diphtheria	12.7	11.1
Tuberculosis—Lungs	70.5	74.0
Influenza and Pneumonia—all forms	145.5	147.5
Dysentery, Diarrhea and Enteritis	32.1	46.6

(*All other rates per 100,000 population)

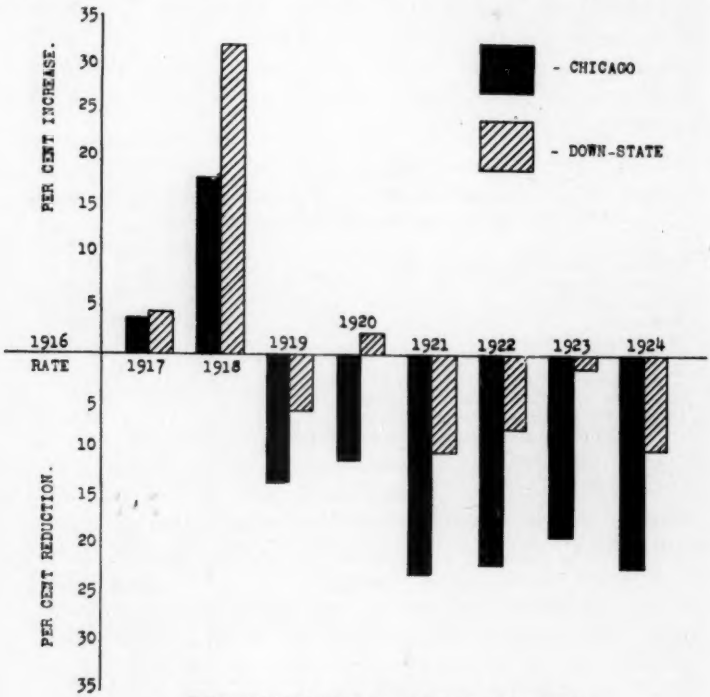
TABLE NO. II.

Mortality rate per 100,000 population, U. S. Registration area. From certain preventable causes—1900-1922—and per cent reduction in these rates, for cities and rural districts.

	Cities.			Rural.		
Disease.	1900	1922	Per cent reduction	1900	1922	Per cent reduction
Typhoid Fever	28.5	4.8	83	34.6	10	71
Malaria	5.4	.9	83	7.2	6	17
Measles	16.4	4.1	75	9.8	4.5	54
Scarlet Fever	11.9	3.6	70	6.8	3.4	50
Whooping Cough	14.4	5.5	62	9.8	5.6	43
Diphtheria	52.4	15.6	70	26.5	14	48
Influenza	24.2	23.6	3.	29.6	38.3	
Tuberculosis (pul.)	204.1	83	59	138	85	38
Diarrhea and Enteritis (under 2 years)	116	35.1	70	56.2	30	47

HEALTH PROGRESS HAS NOT BEEN UNIFORM

In analyzing mortality during recent years, it is interesting to note the difference which exists between different areas and particularly between the urban and rural areas of the country. For several years Chicago has had a more favorable mortality experience than the rest of the state. Nor is this a unique experience. The large cities of the country generally have overcome their natural handicaps, and their death rates compare favorably with their rural neighbors. Since 1917, rural areas in New York state have shown a higher death rate from all causes than have the cities of the state. Illinois is



PER CENT VARIATION BY YEARS IN DEATH RATE FROM ALL CAUSES FOR CHICAGO, AND FOR DOWN-STATE.

(1916 Death Rates Taken as Base Line).

rapidly approaching this condition. In 1922 the death rate in the U. S. Registration area from all endemic, epidemic and infectious diseases was higher in the rural than in the urban areas (rural—186.3, urban 180.4 per 100,000 population).

Of more interest even than this present relative status of city and rural health is the trend of death rates in these two groups during this century. Without exception the rate of decline has been more rapid in the cities, so that at present the rural death rate from tuberculosis, typhoid fever, diphtheria and a number of other preventable causes is higher in the rural districts than in the cities. (See Table No. 2.) Although the decline in the death rate from most preventable causes is gratifying, this is not the case with some of the items on the list. In particular, cancer and diseases of the heart are exceptions to the general trend, and the death rates from the pneumonias and from accidents are still too high. Infectious diseases still cause 35.1% of all deaths.

MORBIDITY DATA

Records of sickness are not available in sufficient extent and completeness to be used alone in determining the state of health of a community. Therefore, little account can be taken of many disabling and yet not killing diseases. With lowered death rates it is known that sickness likewise has decreased, but to what extent is not known. Estimates as to the prevalence of common colds, of certain other minor contagions, of malaria, and of hookworm disease must of necessity be inexact since they can be determined only by special surveys among limited groups. It is stated as a rough approximation that every death represents 100 cases of sickness, and it has been estimated that the average person suffers disability from sickness approximately 8 days per year.

EVALUATION OF HEALTH ACTIVITIES

Morbidity data, then, are not complete, and although mortality data furnish a reliable index of health conditions in large populations, especially when considered over long periods of time, they do not suffice to furnish

a current measure of the health status of smaller groups of population. This fact has been recognized by health authorities, and recently an effort has been made to evaluate community health by comparing health activities. All activities directed towards disease prevention and health promotion may be divided into certain constituent items of service, and an arbitrary value placed upon each item. In assessing a value to the several items of health service the general guides must be:

(a) The relative economic importance of the disease or group of diseases.

(b) The relative preventability of the disease or group of diseases.

(c) The conjectural value of those services not directed specifically against particular diseases.

(d) The psychological response of the people to the service.

By such a method of evaluation the relative efficiency and the relative adequacy of a community's health service may be determined. It follows logically that standards of health service can be set and that health departments may be classified and grouped in a manner similar to the present grouping of medical and other schools. The details of working out such a classification are difficult, and health authorities now are not in full agreement as to the feasibility of such a plan, but it is believed that the day is not far distant when the term "standard health department" or "grade A health department" will be in common usage.

By such a method a community can measure the efficiency and adequacy of its health service and compare it with the health service of similar communities. Such a comparison in itself should serve as a stimulus in providing better health organization, and will enable the public to measure the returns from its health expenditures.

POTENTIAL ACCOMPLISHMENTS

Thus far actual accomplishments in the field of public health have been considered. It has been noted that great variations exist between the present health status

of the different states and cities, and between rural and urban districts. What can be expected from this all-embracing science of public health and the art of its application during the next half century, for instance? To prophesy what the future holds in new discoveries in the field of public health would soon lead one into the realms of fantasy, and at best would be pure guesswork. That additions to scientific knowledge of disease prevention will be made, we know, but the nature and extent of these additions,—whether they be in chemotherapy, in immunology, in nutrition or in some other field, we do not know.

Suppose then we disregard fascinating speculations as to new discoveries which may wipe out some of our modern plagues, and confine our estimates to an appraisal of the potentialities which public health holds if present scientific knowledge is thoroughly applied throughout the country. What potential results are attainable now? In order to err on the side of concervatism, I shall take as the goal which should and can be reached figures in excess of the present minimum death rates (adjusted) of individual states,—rates which are entirely possible of attainment as a national average. The objection may be offered that differences in racial, climatic or other conditions exist which vitiate this basis of estimation. To such objection the fact is submitted that the individual state has a population group more or less cosmopolitan; and granted that climatic influences exist which predispose to certain diseases, this same factor is apt to influence favorably some other group of diseases. Further, it will be conceded that no state has reached the maximum of efficiency in its health service throughout the state, but that it falls short of potential accomplishments by a large margin.

Applying this basis of estimation, the general conclusions reached are that the average life span can be increased from the present 57 years to the Biblical measure of three score and ten; that our present infant mortality rate can be cut in half; that the same may be done with tuberculosis; that typhoid fever and dysentery may be practically eliminated; that diphtheria and scarlet fever can be reduced 75%; that the pneumonia death rate can be materially reduced, leaving

it chiefly as "a friend of the aged"; that malaria and hookworm disease can be banished; and that the economic welfare of the people may thereby be promoted, as can be done by no other means.

The fact that such a large proportion of disease can be prevented in the United States by the application of well known principles should in itself be a spur to further and more effective public health effort. This fact is all the more impressive and the need all the more imperative when we consider that this reduction will take place chiefly among the younger and most productive age groups. Another point which deserves emphasis is that this reduction in preventable sickness and postponable death can be brought about by an expenditure of funds well within the financial ability of every community. Businesslike and scientific expenditures for public health will yield a greater return on the investment than any other expenditure of public funds. Space prevents me from elaborating fully the proof of this assertion.

Without dwelling further upon the general possibilities in the saving of human life through applied public health efforts, let us pass to a more detailed consideration of the methods by which the objectives may be attained.

METHODS NEEDED IN PUBLIC HEALTH WORK

In order that the great mass of the people may receive more fully the benefits to be derived from the practical application of preventive medicine, several basic principles must be borne in mind. These may be summarized as: (a) coordination of effort; (b) application of business principles to health service; and (c) a critical evaluation of current practices with a keen sense of relative values.

In the field of public health the time has arrived when the greatest need is not for differentiation and specialization, but for integration, synthesis and unification. This coordination of effort needs to involve all the sciences represented here today. Very few of you are pursuing science in the abstract; your constant endeavor is to seek new facts in science so as to apply these facts for human betterment. No one phase of science can proceed

far in itself, disregarding all others. Each is closely interwoven with the others and can flourish best, not at the expense of related lines of endeavor, but as a part of an orderly scientific progress.

The predominant need is for a better coordination of the theory and practice of medicine as applied to individual and to community health problems. Hardly less needed is a similar coordination of other branches of science with public health, to which they are inevitably related.

Finally, coordination of effort is needed even within the field of public health itself. The whole problem of health and disease needs to be studied as one problem and not as a series of unrelated subjects.

BETTER HEALTH SERVICE NEEDED

From a practical standpoint this means a unified program of public health under single and competent leadership. It pre-supposes a full-time health officer who studies the health problems of his community, determines upon the most logical program, having a due regard for the relative values of different problems and the procedures, and unites the efforts of all agencies towards their solution. It presupposes adequate health organization, national, state, city and county, supported by an intelligent public opinion.

What should comprise the duties of an adequate health department?

HEALTH EDUCATION

First and most important is health education. Education of the mass of the people must precede any advance by society, and the accomplishments of public health have been due to public enlightenment as to the essential facts of disease prevention and community health promotion.

The field of health education furnishes an example of the coordination of effort between the sciences which I have mentioned. The educational authorities can do much and should bear the primary responsibility for health education during the school age by incorporating in the curricula of the schools adequate courses, suited

to the age of the child, dealing with the various phases of personal and community hygiene. The physical well-being of the child is so directly correlated with his mental growth as to be a very vital concern of school authorities.

CONTROL OF COMMUNICABLE DISEASES

It was for the control of epidemics that health agencies were first created, and although the policy of a health department should be constructive rather than defensive, although it should deal with the positive phases of health promotion as well as with disease prevention, still the prevention of contagion is a fundamental activity of any health department. Efforts at disease control embrace not only quarantine of known cases, but scientific epidemiological investigation of all cases to search out the source of infection as a basis for its elimination. Adequate laboratory service, too, is indispensable to effective health service, and for such diseases as smallpox, typhoid fever, diphtheria and scarlet fever, active immunization of the susceptible population furnishes an added method of attack.

Tuberculosis causes about eight per cent of all deaths, and a constructive program of control should be carried out. The methods which are proving effective are too well known to be recounted here. Almost all health activities influence tuberculosis prevalence, just as efforts directed against this disease benefit general health. A campaign against venereal diseases, participated in by all agencies interested in social welfare, should occupy a part of every health program.

CHILD HYGIENE

Efforts to improve child health are productive of most gratifying results. More can be accomplished in this field when it is considered as an integral part of a general health program than by any other activity. Education of expectant mothers concerning prenatal and infant hygiene, instruction in infant care, the examination of school children for physical, dental, nutritional, and mental defects,—all are necessary health activities.

SANITATION

The provision of safe water and milk supplies and of sanitary methods of sewage and excreta disposal constitute a primary duty of any health department. Recent outbreaks of intestinal disease in Illinois due to water pollution show how incompletely this fundamental sanitary need is met in some communities. In all except the largest cities of the state little or no supervision of milk supplies is maintained.

HEALTH PROMOTION

Nor is the saving of human life the only aim and function of public health. It seeks not only to prevent disease but to promote health. It has a positive as well as a negative mission. Efforts to enhance physical and mental efficiency are assuming an increasing importance in present health practices. Witness the interest in the correction of childhood defects, in improved nutrition, in increasing physical fitness by rational living,—all are ends in themselves by enabling people to live in the fuller enjoyment of life, as well as an additional means to the end of preventing disease by increased resistance.

MENTAL HYGIENE

Mental hygiene is all too slowly finding a place in public health procedures as psychologists, eugenists and biologists make clear the scientific facts upon which it is based. Quality as well as quantity of populations must be given increasing consideration. There are some over-enthusiastic specialists who would have us desist from our usual public health endeavors because, they allege, these efforts serve to protect the unfit. Such a view is not in accord with the facts as known at present. Resistance to disease bears no correlation with mental unfitness. The preventable diseases take their toll among all. The mentally strong and the mentally weak suffer alike. Then, too, there is that vast group in the twilight zone in which either heredity or environment may be the dominant factor in determining whether the individual will be an asset or a liability to society. Who can evalu-

ate the factors in every case? Until science can furnish more clearly the basis for such an evaluation, efforts to mitigate unfavorable environmental factors should not be lessened.

I am not minimizing the importance of the known facts of heredity, or of the hygiene of the mind. They furnish a challenge to the whole scientific world, whose imperious duty it is to bring these facts persistently to the mass of the people to the end that society will take at least the first and most necessary steps in protecting itself from the menace of the unfit. Mental hygiene becomes an increasingly important phase of public health, which is added to but which does not lessen the necessity for physical hygiene. Thus it is seen that education, medicine—in its research and in its application—bacteriology, chemistry, engineering, biology,—all have a very definite relation, and need to have a very definite correlation with public health.

LOCAL HEALTH ADMINISTRATION IN ILLINOIS

Having outlined the scope of the activity of a modern health department, let us review briefly how fully these minimum standards of health practice are met in Illinois:

There are in the state 2717 separate health jurisdictions, each with a board of health. In this total of 2717 health jurisdictions there are only 430 in which the health officer is a physician, and of these physicians only eight are full-time health officers. The remainder are part time, poorly paid practitioners who must look to their practice for their major income. More than 2250 health officers are untrained laymen who occupy the position usually by virtue of their position as village clerk or township supervisor. Manifestly health progress under such a system is impossible. The township and village are too small a unit for health government. For effective rural health work the county has proven the logical unit. The laws of the state, however, do not permit counties under township government to organize a health department. The first need in Illinois, then, is enabling legislation which will permit counties to appoint a health officer and to provide him with sufficient assistance to

carry out an effective country-wide health program such as I have outlined. Efforts are now being made by the State Department of Public Health to secure such legisla ion.

The next need is the active participation of all individuals and organizations, and particularly the leaders in scientific thought represented here today, in educating the mass of the people of the state as to the value and economy of an adequate and efficient health service in which all agencies, working for whatever phase of public welfare, are united in a common purpose.

CONCLUSIONS

In concluding these remarks, I know of no better way of emphasizing the community of interests which exists between all the sciences, and especially the dependence of public health for its sustenance upon so many branches of science, than to quote the words of that master scientist and teacher, Sir William Osler:

"The salvation of science lies in a recognition of a new philosophy—the scientia scientiarum of which Plato speaks: 'Now when all these studies reach the point of intercommunion and connection with one another and come to be considered in their mutual affinities, then, I think, and not till then, will the pursuit of them have a value.'"

ATTRIBUTES OF THE HUMAN ORGANISM

Dr. R. V. Brokaw, Superintendent of City Health Department, Springfield

An eminent scientist has said that "science is verifiable, communicable, impersonal, unemotional knowledge". He further states that "the scientific mood is marked by (1) a passion for facts, (2) a cautious thoroughness in coming to a conclusion, (3) a quality of clearness, and (4) a less readily definable sense of the inter-relations of things".

While I freely admit that the paper which I present for your consideration at this time is not sufficiently impersonal and unemotional to be strictly scientific, yet I believe it embodies enough of the scientific mood to justify its presentation; for its essential purpose is the delineation of a striking uniformity which pervades the entire universe.

To say that science has made tremendous advances during the last half century is platitudinous. The important observation is that the artificial barriers erected by misconception are rapidly being torn down, and former "irreducibles" are undergoing reduction. The amalgamating process is reflected in the increasing use of such terms as "physico-chemical", "bio-physical", and "psycho-biological". The analytical process is illustrated by the successive revision of our conception of the character of matter from that of solid integrity to molecular discontinuity, atomic divisibility, and electronic componency. Science at present is very actively engaged in the unification of diversities and in the discovery of uniformities.

In the development of my thesis, I shall successively consider (1) the distinction between organic and inorganic matter, (2) the similarities of animal and vegetable life, (3) the relation of man to the animal world, (4) the connection of the human mind and brain, and (5) the metaphysical aspects of the human organism.

Obviously, the occasion permits but a cursory review of the theories and facts involved, and the evidence submitted must be fragmentary. As to originality in this work, I confess with Kipling—

"When 'Omer smote his bloomin' lyre,
'E'd 'eard men sing from sea to sea;
And what 'e thought 'e might require
'E went and took, the same as me."

ORGANIC AND INORGANIC MATTER

We have been accustomed to draw a sharp line of demarcation between the organic and the inorganic, the mineral and the biological kingdoms, the so-called living and the so-called dead. For centuries, we have attributed to the biological world a directive life process; a supreme, controlling "vital force" inherent in organisms but absent from the mineral kingdom.

The eminent Huxley (1825-1895) once said, "The present state of knowledge furnishes us no link between the living and the non-living". But when this statement was made Wohler (1800-1882), a German chemist, had already (in 1828) produced a typical organic substance (urea) from inorganic matter by simple laboratory methods, entirely without the directive influence of a "vital force".

And since that achievement, hundreds of carbon compounds long thought to be peculiar to organisms have been produced by chemical synthesis from inorganic substances. Emil Fischer, for instance, has artificially produced a very complicated compound, consisting of eighteen amino acids, fifteen molecules of glycin, and three of leucin, which in many respects resembles a natural peptone; and working along the same lines, it seems only a question of time until synthetic proteins can be made out of lifeless material in the laboratory. In fact, the fundamental laws of organic and inorganic chemistry are identical; and it is very probable that ultimately the artificial synthesis of every organic substance may be accomplished.

Contrary to Huxley's view, therefore, a link has been established between the living and the non-living; and the line of demarcation begins to fade.

Additional evidence of the uniformity of living and non-living matter is presented by our new conception of the essential character of the atom. This formerly

"indivisible" ultimate unit of matter has been dissected, and resolved into its component parts of "proton" and "electron", which in turn have been identified as positive and negative particles of electricity. It is also generally accepted that these particles constitute every atom of whatever kind; and it is therefore quite logical to infer that all matter, of whatever character, is but a manifestation of electricity.

This principle, then, pervades the whole physical creation: electrons combine to form atoms; atoms combine to form molecules; molecules are the bricks with which everything is built—the crystal, the flower, the animal, man, the stars, the entire universe. On this, our greatest scientists agree.

Another important consideration regarding the uniformity of matter is the fascinating theory of inorganic evolution. This theory is not new; but it has recently acquired a new significance as a result of very interesting observations made in connection with the spontaneous disintegration of radio-active substances and experiments on the x-ray spectra of the elements.

Moseley (a brilliant young Englishman who was killed in the recent war) is responsible for an entirely new conception of the mutual relations of the elements. On the basis of his work with certain x-ray spectra, it has been conclusively demonstrated that the characteristic number of electrons in the atoms of the several elements increases with definite mathematical regularity from the lightest and simplest, hydrogen (number 1 in the series), to the heaviest and most complex, uranium (number ,92 in the series). An arrangement of the elements on the basis of Moseley's "atomic number" has now been accepted as more fundamental than Mendeleeff's periodic system based upon atomic weight; although the two systems are practically coincidental. This orderly progress of the elements from simple to complex structure is very suggestive of an evolutionary series in the mineral kingdom.

The behavior of radio-active substances indicates that the more complex elements are built up of the simpler elements. When, for example, the complex atom of

uranium spontaneously disintegrates, one of the cleavage products is the simple atom of helium.

The transmutation of elements has been artificially accomplished. Sir Ernest Rutherford has bombarded the nitrogen atom with alpha particles and split it into hydrogen and, probably, helium. According to a very recent report, he has likewise succeeded in disintegrating the atoms of aluminum, sodium, potassium, boron, phosphorous, fluorine, magnesium, silicon, sulphur, chlorine, and argon. The evidence very strongly suggests that all elements, and therefore all matter, may eventually be found to consist of various combinations of the comparatively simple atoms of hydrogen and helium.

The question of the evolution of the elements has been considered from another angle. Lockyer, the English astronomer, has suggested that the elements composing the stars are in a state of inorganic evolution. In the hottest stars, hydrogen and helium predominate; and in the cooler stars, the heavier elements appear. On this basis, it is inferred that the light elements combine to form the heavier elements as the temperature decreases. Rutherford states in this connection, "There can be little doubt that conditions have existed in the past in which electrons have combined to form the atoms of the elements, and it may be quite possible under the very intense electrical disturbances which may exist in hot stars that the process of combination and dissociation of atoms still continues."

While it is quite true that we have seen the spontaneous disintegration of complex atoms into simpler ones, and have artificially accomplished this result, we have still to behold the contrary process of combining simple atoms to produce the heavier, complex ones. Moreover, it is very probable that the electrodynamic forces involved in such a combination are of so great an intensity as to postpone this experimental achievement to a distant future.

If we accept the theory of inorganic evolution (and I think that no rational mind which has examined the evidence can avoid the conclusion), it is quite logical to believe that at some point in the development of the structural complexity of inorganic matter the conditions

of primordial life were fulfilled. In this manner, spontaneous generation may be said to have occurred.

Personally, I can see no objection to this hypothesis of the first origin of life. As Hertwig puts it, "Whoever, in agreement with the teachings of astronomy, adopts the view that our earth was at one time in a molten condition and has gradually cooled, must assume that life on the earth has not existed from eternity, but at some time has had its beginning. If he wish to base his explanation, not upon a supernatural act of creation, nor upon hypotheses like that of the transference of living germs from other worlds through the agency of meteors, there is left only the hypothesis that, according to the generally prevailing and still to be observed laws of chemical affinity, compounds of carbon, oxygen, hydrogen, nitrogen, and sulphur have been brought together to produce living substance."

While we have as yet no definite knowledge of the origin of life, everything points towards the conclusion that, in the evolutionary development of the inorganic realm, simple atoms combined to form complex atoms, simple molecules combined to form complex molecules, complex molecules combined to form aggregations of matter which had the power to reproduce themselves. Thus life began; not as the result of the violent interjection of a special "vital force", but as the summation of extremely complicated chemico-physical processes. And from these primitive vital substances, by a slow and continuous process of evolution, the present animal and vegetable forms have emerged.

ANIMAL AND VEGETABLE LIFE

For the sake of completeness, let us now briefly consider, somewhat parenthetically, the similarities of animal and vegetable life.

Thomson (J. Arthur) suggests that the genealogical tree of living creatures may be likened to a letter V. On the one side are animals; on the other side are plants; at the base there are simple forms of life which have not taken any decisive step in either direction.

To the ordinary observer, there seems to be a very marked distinction between plants and animals: plants

are made of wood, animals of flesh; plants take in carbon dioxide and give off oxygen, animals reverse this metabolic process; plants are stationary, animals move about; animals have brains, plants do not.

To the scientific observer, however, this distinction is not so clear. For instance, the tunicates, which are very highly organized animals, have an abundance of cellulose in their bodies. Examining closely the metabolism of plants, we find that in the performance of its vital functions the vegetable protoplasm, like the animal, consumes oxygen and produces carbon dioxide. As far as movement is concerned, some of the bacteria, which are definitely vegetable, have very marked powers of locomotion; while such highly organized animals as the barnacles live completely sedentary lives. As to the absence of brain in plants, it is very interesting to note that none of the protozoan animals have the slightest evidence of organized nerve tissue; and not until the flatworms are reached in the ascending scale of animal complexity is there any semblance of a brain. On the other hand, how can we explain the marvelous ingenuity of plants in certain modes of behavior, and on what basis can we deny them intelligence?

The fundamental uniformity of animal and vegetable organisms is manifested by (1) their common origin from primitive vital substance, (2) their incorporation of similar chemical constituents, and (3) their joint possession of the peculiar functions of life, namely, metabolism, growth, reproduction, and internal powers of adaptation to environment.

MAN AND ANIMAL

It would be ridiculous, in this age of intelligence, to raise the question of man's relation to the rest of the animal kingdom were it not for the fact that stupid legislators and bigoted "fundamentalists" are still broadcasting their denial of the theory of evolution.

Lamarck (1744-1829), the French zoologist, was one of the early proponents of the theory of evolution. He taught that the first simple organisms of the earth arose in a natural way through spontaneous generation from

non-living matter; that the present species of plants and animals have developed from these simplest living creatures by gradual changes, in the course of an immeasurably vast space of time, and without any break in the continuity of life upon our globe; that man is the terminal point of this series; and that all the other animals are the descendants of those forms from which man has developed.

Later, Darwin (1809-1882) modified Lamarck's theory by the important addition of his doctrine of the causes of evolution, as set forth in his "Origin of Species". And more recently, Mendel's (1822-1884) work has revolutionized our conception of the laws of heredity. Like every sound doctrine, the theory of evolution is in process of evolution; but the fundamental fact that man is an animal is beyond controversy.

It is obviously impossible, within the limi s of this paper, to present anything more than a mere suggestion of the mass of evidence supporting the theory of evolution: the uniformity of chemical constituents and cellular composition; the increasing complexity of organic structure and function; the paleontological evidences of progression; the transitional forms between the great divisions of animals; the phylogenetic recapitulation by the individual animal in its embryological development.

That man is an animal physiologically, the everyday functions of the human body amply demonstrate. Comparative anatomical evidence is equally convincing. Embryologically, he recapitulates the entire series of lower animal forms. Psychically, he duplicates many of the faculties of the brute. When all these lines of evidence are considered, they are seen to converge in the conclusion that man is identical with the rest of the animal world, built of the same stuff, functioning in the same way, although on a higher plane.

As Darwin says: "We must acknowledge, as it seems to me, that man with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men but to the humblest living creature, with his God-like intellect, which has penetrated into the movements and constitution of the

solar system—with all these exalted powers—man still bears in his bodily frame the indelible stamp of his lowly origin."

MIND AND BRAIN

In considering the connection of the human mind and brain, it might be interesting to note, in the first place, that the brain has not always been recognized as the exclusive "seat" of consciousness. This is illustrated by the phrase, "bowels of compassion". As Shakespeare said, "Thou thing of no bowels." And still another (Fuller), "That corpulent tyrant, full of guts, and empty of bowels". Did not the Psalmist exclaim, "O Lord, strengthen me in my reins", that is, "in my kidneys"? Someone has also said, "As a man thinketh in his heart, so is he." And we still refer many of our mental states to this organ.

"That the phenomena of our conscious life are connected with the actions of the brain is suggested by the fact that mental excitement, strain, or fatigue is apt to induce sensations which we commonly localize in the head. It is still more distinctly suggested by the common observation that an injury to the brain produces unconsciousness. When to such common observations science added the fact that the brain is the great central station or meeting point of the nervous system, the inference that it has a special significance as an organ of mind became inevitable." (Sully, Outlines of Psychology.)

Furthermore, physiologists "believe that every state of consciousness is correlated with some definite molecular change in the substance of the nervous system, in such a way that a being possessed of sufficient intelligence could infer the character of the state of consciousness from the knowledge of the molecular change, or infer the molecular change from the knowledge of the state of consciousness". (Rice, W. N.) Molecular changes in fatigued brain and nerve cells of certain animals have been already microscopically demonstrated by several investigators.

The interdependence of mind and brain, and a definite correlation of nervous and psychical processes, is gener-

ally accepted by physiologists and psychologists; but the precise nature of this relationship has been a subject of argument for centuries, with no satisfactory conclusions thus far.

The mechanistic, or materialistic, theory holds that mind is a direct product of the brain: as the liver secretes bile, so the brain secretes thoughts. The contrary theory presumes that mind is the reality, and the body has only a phenomenal existence. Animism attributes to each living body a soul, which is the directing force of all its mental and physical processes.

Monism assumes that both the mental and material are real, or self existent, but are not independent realities. Consciousness, the fundamental property of mind, and extension, the fundamental property of matter, are conjoint attributes of one and the same substance. Thus the ultimate reality or fundamental substance is neither spiritual alone, nor material alone, but both.

Wundt (1832-), the German psychologist, says: "The ego is not compounded of body and soul, but is a determinate stage of evolution of being, which, contemplated from different standpoints, divides itself into bodily and spiritual being."

The monistic, or two-aspect, theory, which postulates a psycho-physical being, functioning at once as mind-body or body-mind, is perhaps more acceptable to the scientists of today because it does justice to the extraordinary interactions of mind and brain, and is not inconsistent with the theory of psychic evolution.

That the mind is a product of psychic evolution, just as the body is a product of organic evolution, certainly is a plausible theory. Herbert Spencer (1820-1903) has said, "If the doctrine of evolution is true, the inevitable implication is that mind can be understood only by observing how mind is evolved."

Psychologists of today do not place intelligence in sharp contrast to instinct, as was formerly taught, but rather regard it as an evolutionary product of instinctive behavior. And, in turn, as Whitman suggests, "The primary roots of instinct reach back to the constitutional properties of protoplasm, and their evolution runs, in general, parallel with organogenesis."

To carry this hypothesis to a logical conclusion, we must also assume that something akin to consciousness exists in connection with inorganic substances; and thus we may attribute to every form of matter a quasi-mental aspect.

RECAPITULATION AND CONCLUSION

In closing this paper, may I briefly recapitulate, and draw a few conclusions.

All matter is apparently a manifestation of electricity. The theory of inorganic evolution has acquired a new significance. The first origin of life has probably occured as a summation of complicated physico-chemical processes in the mineral kingdom. The artificial production of complex organic substances has rendered less distinct the line of demarcation between living and non-living matter. Man is a product of organic evolution, and is identical with the rest of the animal world. Organic evolution is a direct continuation of inorganic evolution, with hydrogen at the beginning and man at the end of the evolutionary series. Mind is coexistent with matter. Psychic evolution parallels inorganic and organic evolution. The metaphysical attributes of the human organism may be sublime functions of matter. As time is the fourth dimension of a cube, so may immortality be a fourth dimension of the human organism. A profound uniformity of constitution and behavior pervades the entire universe.

None of these postulates is inconsistent with a rational interpretation of prevailing religious and theological tenets. The more closely we analyze the constitution of the human organism and the more carefully we scrutinize its behavior, the greater, and certainly the more intelligent, reverence we gain for the profound facts of human existence. Man loses none of his divinity and God loses naught of his majesty in the process.

GRAPHICAL REPRESENTATION OF THE THEORY AND PRACTICE OF X RAYS

CHARLES T. KNIPP, UNIVERSITY OF ILLINOIS

Practically the whole development of electrical science has taken place within the lifetime of many of us. True, the fundamental discoveries of Faraday in England, and Joseph Henry in America were before our time; they were advance signals, as it were, of what was soon to follow. Even in the seventies little or nothing was known of what we today consider the absolute necessities of life —the telegraph, the telephone, the electric light. The dynamo was an uncertain machine, and induction as used in our present lighting systems was undreamed of. Nevertheless, the scientific spirit was among physicists and chemists, and enthusiasm ran high with the result that the world was about to enter upon a new era of practical achievements based upon scientific investigation. Maxwell in England and Helmholtz in Germany were leaders in pure science, and we may consider Edison and Graham Bell in America as the leaders in making practical applications. Maxwell in the seventies, by intuitive and unparalleled mathematical reasoning, arrived at the now famous "Maxwellian equations" in which he enunciated that light waves are a manifestation of a universal, and almost unlimited in extent, phenomena ranging in wave length from, say, one hundred thousandths of a centimeter up to many kilometers, and what we call visible light consists simply of a small portion, about one octave, of this gamut of wave lengths. This was indeed a startling enunciation and required experimental proof before it was even universally adopted among physicists and mathematicians. It came at the time, or rather, shortly before the dynamo was invented, the telegraph was perfected, and the transmission of speech over wires to distant points was being utilized practically. Nor was the experimental proof that light waves are electromagnetic waves long in coming. Heinrich Hertz, a brilliant young German physicist, was the first to show experimentally that electrical energy could be transmitted to a distant point without the intervention of wires. His experiments, made in the middle eighties, formed the in-

ception of our modern radio, though it was not until about ten or fifteen years later that wireless telegraphy assumed commercial proportions in the hands of Lodge, Marconi, Fleming, and others.

Electrical science made rapid strides following the experiments of Hertz. The direct current dynamo was perfected, the telephone was no longer a toy, and the underlying principles of alternating current generators and the transmission of power was being worked out. Greater advance was recorded along electrical lines during the twenty years prior to 1895 than had been made in two hundred years previous to 1875. All centers of learning were imbued with the desire to do research; yet the feeling arose generally among physicists the world over in the early nineties, and became more insistent, that practically all of the great discoveries had been made, that little more could be expected than greater refinement in making measurements; in short, all that the scientific world could expect to do was to polish off the fourth and fifth decimal places. This pessimistic outlook upon the future of science has been completely shattered by the brilliant sequence of discoveries that have been made since 1895. The discoveries of the last thirty years are unprecedented in the world's history. Nor are we at the end in this the year 1925. Not again will it be said that the great discoveries have all been made, not so long as the lure of scientific discovery and invention is uppermost in the minds of the earnest horde that make up the research fraternity of the present age.

Let us enumerate briefly some of the really great discoveries of the last thirty years. On the year following the period of scientific depression, referred to above, was made one of the greatest discoveries of them all, the discovery of X rays by Professor Roentgen of Berlin. Then came the brilliant work of J. J. Thomson and his associates on the discharge of electricity through gases, in which the "electron", now almost a household term, was isolated and its properties determined, followed in 1909 and 1910 by the first of that striking and important series of experiments on positive rays which at the present time, in modified form in the hands of Aston of Cambridge, England, and Dempster, of America, is yielding

results which in no small degree are furnishing inside information on that perplexing problem of the ultimate structure of matter. Another discovery of the greatest importance was that of radio-activity by Becqueral of Paris.

As usual, the scientific staff at the Cavendish Laboratory, Cambridge, England, took up the cue and Ernest Rutherford, a native of Australia, made astonishing discoveries as to the properties of the radio-activity emitted from radio-active material. A contributor in this line of research second only to Rutherford is Mme. Curie of Paris. The discovery of radio-activity gave to science a powerful tool in the further study of the ultimate structure of matter. Radium, for instance, emits three types of radiation known as alpha, beta, and gamma rays (so named by Rutherford). The alpha rays are electrically charged atoms,—atoms of helium. They are thrown off continuously from, say, radium, and in spite of their minuteness (it would take about 500,000,000 alpha particles placed side by side to make one centimeter) it is possible to make the effect of a single alpha particle visible. In the hands of Rutherford this effect revealed itself as a flash of light when an alpha particle struck a willemite screen. Shortly after this C. T. R. Wilson, by the aid of his cloud experiments, was able to show the presence of the alpha particle by a line of condensation of water vapor left in the wake of its path. These alpha-ray tracks, as they are now called, may be, under favorable conditions, three or four centimeters long and can be produced by exceedingly simple apparatus. The discoveries arising out of the discovery of the electron by Thomson and of X-rays by Roentgen formed the starting point of manifold industrial developments. The modern triode vacuum tube and the unbounded success of radio of today resulted from Thomson's work of a quarter of a century ago. "We come nearer knowing what electricity really is from the study of the discharge of electricity through gases than from the flow of electricity through metals or through electrolytes." The discovery of X-rays in 1895 took the world by storm. Every physics laboratory having Crookes vacuum tubes in its possession at once tested these for X-rays. Nor were their efforts

disappointing, for many of them made 10 or 15 years before were found on testing to give X-rays. Marked enthusiasm in X-ray research followed. Many workers were attracted by the practical aspects, and we have at the present day X-ray outfits for every possible need,—the surgeon, the dentist, the shop merchant, the manufacturer in the testing of materials, and the bacteriologist as well. Others, possibly with no thought of the utilitarian, sought, for the pure joy of discovery, to use the X-ray as a possible means of attack in the solution of that ever fundamental problem of the ultimate structure of matter. They are being rewarded. We now know definitely what X-rays really consist of.

They might more appropriately be called Roentgen rays in honor of their discoverer, though it seems that the term X-rays even yet stands in better favor.

Earlier in their history physicists were perplexed by not being able to reflect, diffract, refract, and polarize X-rays in the same manner that light rays are reflected, etc. Many attempts were made without success, when about fifteen years ago Professor Laue of Munich, Germany, made the brilliant prediction after an involved mathematical analysis of the subject that X-rays, if they are a wave phenomenon, should be reflected, refracted, and indeed diffracted by a crystalline substance where, as crystallographers tell us, the molecules of the crystals are in definite layers and therefore the interfaces should be smooth, infinitely smoother than the fines polished glass surface, and the X-rays falling on these surfaces should be regularly reflected. This was at once put to test and confirmed. The scientific world, as if by magic, turned to this new discovery of Laue. Theories of X-rays irrelevant to this were dropped. The Braggs in England, and Hull in America led the way, and now investigations based upon the wave theory of X-rays are in progress in almost every research laboratory of note. It is as common to speak of X-ray spectra now as it was of light a few years ago. By means of these spectra new substances are being discovered, and the relationship to the order of an element in the periodic table—Moseley's law—was established.

The theory of Laue so beautifully confirmed by experiment suggests at once the extreme shortness of the wave length of X-rays. The highest polished glass surface is as a surface of shot in comparison to the wave lengths falling upon it in the form of X-rays. It is for this reason that the reflection and refraction of X-rays so long eluded the most painstaking research. It is also because of the extreme shortness of the wave length that X-rays are so penetrating.

It is interesting in this connection to study the wide range of electromagnetic waves. Fig. 1 is a graphical representation.[1] The entire gamut is shown, from the longest Hertzian waves to the shortest gamma waves—a range of over 48 octaves. This graph reveals many interesting features. For instance, that portion of Hertzian waves that is used in wireless and radio covers a range of but 4 or 5 octaves, while the Hertzian waves of all lengths occupy about 23 octaves. Heat waves occupy 8.5 octaves, and the visible light spectrum but one. It should be noticed that between the Hertzian waves and the heat waves is a region of 3 octaves that has as yet not been explored. This is because the wave lengths are too short to be measured by wireless apparatus and too long to be measured by the present designed methods for measuring heat wave radiations. Beyond the visible spectrum comes the ultra violet region of one octave, and a region beyond which until recently was unexplored,—but now is known to be the upper limit of the X-ray region. In other words, it is definitely known that X-ray waves now begin in the ultra violet region and extend to the end of the graph—the gamma rays shown (one octave) are the short X-rays emitted by radio-active material. It is of interest to note the relative position that the seven octaves of the ordinary piano occupy on this scale of wavelengths. Of course sound waves are not electromagne ic waves as is explained in a footnote on the graph.

In Table I are tabulated some of the data listed in Fig. 1. In column two the wave lengths are expressed in centimeters, while in column three these same lengths

[1] Graph prepared by Professor F. R. Watson, Department of Physics, University of Illinois.

THIS CHART WILL BE THE FIRST CHART
APPEARING AT THE END OF THIS FILM

are expressed exponentially. It should be noted that the gamma rays and X-rays overlap; however, in the remaining rays the limits are distinct.

TABLE I.

Wave Lengths of Electromagnetic Radiations

Kind of wave	Wave length in cms.	Wave length in cms. Expressed exponentially
Hertzian waves.....	2,000,000.0 to .2	2.0×10^{9} to .2
Unexplored	.2 to .031	.2 to .031
Infra red rays.....	.031 to .000072	.031 to 7.2×10^{-5}
Visible light.....	.000072 to .00004	7.2×10^{-5} to 4.0×10^{-5}
Ultra violet rays.....	.00004 to .000002	4.0×10^{-5} to 2.0×10^{-6}
X-rays	.000002 to .0000000006	2.0×10^{-6} to 6.0×10^{-10}
Gamma rays	.000000014 to .0000000001	1.4×10^{-8} to 1.0×10^{-10}

NOTE.—The range covered from the longest Hertzian waves to the shortest gamma rays is about ten thousand million million fold! And the only break in this sequence is a small gap between the Hertzian waves and infra-red rays that have not as yet been explored.

Lastly, we have in Fig. 2 a graphical representation of the present status of X-rays. This graph does not claim to be complete; however, it is suggestive. Some of the more important properties of X-rays are set down, and the uses to which X-rays are put is included under two heads:—first, practical applications, and second, the study of the ultimate structure of matter. It is common observation that the most abstract investigation of today may result in the greatest practical importance to-morrow. An interesting phase under practical applications is "X-rays and industry". This is divided into two parts which may be styled X-ray crystallography and industrial radiography. Since the study of X-rays by means of crystals, introduced by Laue and the Braggs, a new field in the practical application of X-rays has been opened. We can now study the physical properties of

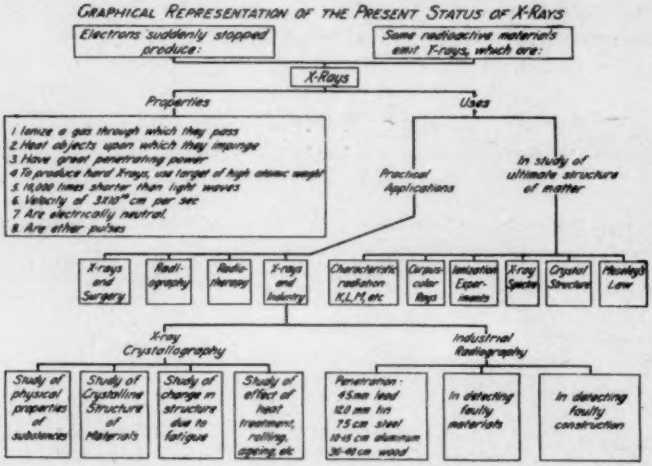

Graphical Representation of the Present Status of X-Rays
Electrons suddenly stopped produce:
Some radioactive materials emit X-rays, which are:
X-Rays
Properties
Uses
1. Ionize a gas through which they pass
2. Heat objects upon which they impinge
3. Have great penetrating power
4. To produce hard X-rays, use target of high atomic weight
5. 10,000 times shorter than light waves
6. Velocity of 3.10^10 cm per sec
7. Are electrically neutral
8. Are ether pulses
Practical Applications
In study of ultimate structure of matter
X-rays and Surgery
Radiography
Radiotherapy
X-rays and Industry
Characteristic radiation K,L,M, etc
Corpuscular Rays
Ionization Experiments
X-ray Spectra
Crystal Structure
Moseley's Law
X-ray Crystallography
Industrial Radiography
Study of physical properties of substances
Study of Crystalline Structure of Materials
Study of change in structure due to fatigue
Study of effect of heat treatment, rolling, ageing, etc
Penetration: 4.5 mm lead 12.0 mm tin 7.5 cm steel 10-15 cm aluminum 30-40 cm wood
In detecting faulty materials
In detecting faulty construction

Fig. II.

substances, their crystalline structure, the change in structure due to fatigue, due to heat treatment, rolling, ageing, etc. Again, since the introduction of the Coolidge X-ray tube, industrial radiography has moved forward to an enviable position. The penetration that is now obtainable is nothing short of marvelous. With present day outfits X-rays become a menace to people across the street. Brick walls are readily penetrated, and photographic plates a block away (if in direct line of the radiation) may be fogged. With greater penetration came lesser time of exposure. Ordinary X-ray exposures require now but a fraction of a second.

The graph, while not complete, shows in a most striking way the wonderful scope the X-ray has assumed. In many lines the work has only been well begun. The practical applications seem to be without limit, and the theoretical and experimental studies with X-rays as a tool bid fair to soon solve that outstanding problem, what is the ultimate structure of matter?

Laboratory of Physics
University of Illinois
February 16, 1925

THE MIGHTY AMAZON

W. H. Haas, Northwestern University

The Amazon is the master stream of the world.* Its sheer bigness is a handicap to the development of its basin. Most naturally the early Spanish explorers called it "mar dulce", fresh water sea. Its drainage basin is nearly twice that of the Mississippi and is comparable to the total area of the United States.

Extending along and more or less parallel to a region of heavy tropical rainfall the river discharges a volume of water four times that of the Mississippi and more than all the rivers of Europe combined. The mean discharge is given as 2,692,000 second feet; and these grayish waters, drifting northwest with the equatorial current toward the Carribean Sea, ride upon the heavier blue saline waters of the Atlantic some three hundred miles before they lose their identity.

In travelling on an ocean liner from port to port on the Amazon one scarcely can grasp its immensity, it seems so little like a river of one's acquaintance. Iquitos, Peru, nearly two thousand miles from the Atlantic, is an ocean port. It is as though the Potomac River extended almost across the North American continent, and a town on its banks in the vicinity of Denver were an actual ocean port. Any of the ocean liners touching South America would have no difficulty at any season of the year in reaching Manaos, about one thousand miles from the Atlantic. Although the depth varies from place to place, the deepest section for the entire stream width is at the Obidos narrows, where no bottom can be found less than eighty-three meters, roughly two hundred and fifty feet. Soundings show other places still deeper locally up to over three hundred feet. It is this great depth that gives the river its quiet rippleless majestic flow of from one to seven miles per hour. The flow is sufficiently strong so that even the big ocean liners hug the banks in their up stream journey and take mid stream on their return, which under similar conditions takes only about one-half the time.

* For details see: Conpendio de Chorographia do Brasil, pp. 66-69.

THE GEOLOGICAL HISTORY*

The geological history of the Amazon is based on similar large conceptions. Both the Brazilian and the Guyana plateaus are made up chiefly of very old rocks similar to the Canadian Shield, generally known as Pre-Cambrian gneisses and schists. These two are now separated by the Amazon inner basin, relatively very narrow in the east at the outlet and increasing in width to the west. Along the south margin of this basin is a fairly abrupt drop from the plateau causing numerous falls and limiting navigation. Roosevelt in his book, "Through the Brazilian Wilderness," vividly describes the difficulty of passing this series of falls.

This inner basin of the Amazon is not erosional but structural. The river flows along a great synclinal basin dipping to the west. The limbs of the syncline, therefore, spread out V-shaped with the opening to the west. This plunging syncline begins in the eastern part of the state of Para, and its dip to the west is sufficient to lose its surface identity in the longitude of Manaos, a thousand miles from the Atlantic. If the syncline extends farther to the west, the limbs are now obscured by later deposits.

Within this structural basin were deposited sediments of Paleozoic age, the youngest appearing farther west, lapping up against older deposits to the east. As the formations are marine, the deposits were made by an arm of the sea coming in from the west. In time the region was elevated and rivers flowed over the surface to the sea, in the west. The drainage of the region for an extremely long period of time was to the west. The drainage is believed to have been reversed with the elevation of the Cordillera in Miocene time. At first many lakes must have been formed, and finally an enormous lake covered what is now the upper part of the inner basin. With the rising waters an outlet was

* Based chiefly on
Branner; Bull. Geol. Soc. of Am., Vol. 30 (1919), pp. 189-339. Outlines of the Geology of Brazil.
Schuchert: Jour. of Geol. Vol. 14 (1906), pp. 723-740. Geology of the Lower Amazon Region.
Katzer, Frederich: Grundzuge der Geologie des Unteren Amazonas Gabietes, (1903).
Le Cointe, Paul: L'Amazonie Brésillienne. (This two volume work in French is by far the best treatment on the whole region.)

found to the east and thus started the Amazonian waters along their present course.

Later in the time that the master stream flowed to the west, erosion had gone on to such an extent that the river had cut in places a very wide flood plain, especially in its lower or western part. The flat topped hills to the north, seen so clearly from the river between Almeirim and Obidos, are believed to represent the northern boundary of the old flood plain. Across the river at Santarem are the now rounded hills representing the southern bluffs. These altitudes and distances between these hills are a measure of the cutting by this ancient stream and its tributaries. Some of the tributaries had cut even deeper than the present drainage is able to care for and have not yet been filled.* The Tapajos, Xingu, Tocantins, Negro, Uatumá, and Trombetas are examples of this type, Hudson Rivers on a grander scale.

The picture of the inner basin, therefore, is one of a vast lowland lying between two ancient crystalline rock masses partly filled with sedimentaries. Into these sediments streams had cut fairly deep valleys, wide in their lower courses, narrower above. With the reversal of flow the lower areas were filled with Tertiary and Quaternary alluvial deposits, but some of these areas still lie below even the low stages of the water table, others suffer from the seasonal inundations. Although, in general, these lowlands border the streams, in many places the older and higher inter-floodplain areas now border the Amazon and give good sites for the location of the towns along the way. Even the Island of Marajo, at the mouth of the Amazon, in its eastern and southern parts is such a higher land mass with a thriving cattle industry, and only on the west and north are there the low alluvial areas, undeveloped of course.

The Amazon is not a rapidly aggrading stream as is frequently concluded from the many islands and lakes, although there are many more of these than the best maps show. The river is not even muddy in the sense that the term might be applied to the Missouri or even the Mississippi. Its waters have an ashen grey tinge in

* Smith, H. K.: Brazil, the Amazons and the Coast. p. 628. See also Hartt, Bull. Cornell Univ. (Science) vol. 1, p. 19.

the lower course, but when dipped up it scarcely appears turbid, at least during the period of low water, and carries relatively little sediment even during high water. The waters of most of the tributaries appear either blackish or dark brown in mass, but practically colorless when in a glass. This is especially true of the Negro, of Japura, Putumayo, Javery, Jutihy, Jurma, Teffe, Purus, Madeira, Tapajos, Xingu, and others. The great basin is filling so slowly that very large areas are not yet high enough for trees to have gained a foothold, and as far as the eye can reach is one vast sea of grass.

The problems underlying any attempt in making this vast region with its enormous resources of a kind serve man more fully than it has been are likewise comparatively equally great. Space forbids even a partial outline. The acidity of the soil, the problem of the water, the clearing of the land, the keeping down of obnoxious grasses after a few years of crops, the getting of products to markets, the finding of a market for the agricultural products that will grow, the insect pests, the inability to keep food or clothing for any period, the enervating climate—all, especially when taken conjointly offer problems which, viewed in the light of present knowledge, seem insuperable. That, however, does not mean that this region will not be used ultimately much more intensively than it is now. It undoubtedly will, but probably along lines of present conditions. The time must come and will be soon at hand when these vast spaces will be studied and exploited along lines which recognize the natural conditions.

SOME PROBLEMS OF THE WEATHER MAN

CLARENCE J. ROOT, U. S. WEATHER BUREAU, SPRINGFIELD

When we meet friend or stranger the opening topic of conversation usually pertains to the weather. This has probably been true back through the centuries, but our ancestors had rather vague ideas concerning the causes of atmospheric phenomena. Even as late as one hundred years ago the law of storms was not understood. As the knowledge of weather and climate increased there came a demand for some organized effort to study these problems and render service to the public, until now the meteorological service is a part of nearly every government. To the late Professor Cleveland Abbe, with the backing of the Cincinnati Chamber of Commerce, is due the inauguration of the present system of telegraphic weather reports. The service was begun on September 1, 1869, with thirty stations reporting. The Weather Bureau was originally a part of the Signal Corps of the United States Army, but in 1890 it was transferred to the then new Department of Agriculture.

The activities of the Weather Bureau at the Central Office in Washington are distributed among a number of divisions, each under the direction of a supervising official. The stations in the field, however, must handle many phases of the work. The major portion of the duties at the Springfield station are in connection with the Climatological Service. One station in each state is designated the section center. The Springfield office directs the work of the 81 meteorological substations, issues bulletins containing the data from these stations, publishes a weather-crop report for Illinois each Wednesday, and supervises the distribution of forecasts in the State.

Through the public-spirited cooperation of nearly five thousand men and women—just such citizens as Messrs. Bonnell, Colyer, and Oglevee of this organization—the climatological service through its cooperative observers has been established in almost every nook and corner of the country, and even extended into Alaska, Hawaii, and the West Indies. The reports from these stations are in great demand. The problem is to "carry on", and

to extend the service into remote and inaccessible places where it is difficult to secure observers but where records are needed to aid settlers in developing the country. Before leaving this subject I wish to make mention of Mr. John West James, who maintained a most excellent record at Riley, near Marengo, covering a period of 54 years on the same farm, never losing more than a day or two at a time, and only terminating his services when called by death. Observations taken by officers of ships at sea are more complete than those made by the co-operative observers on land. They were formerly delivered to the Weather Bureau at the termination of the voyage, but are now forwarded by radio.

No weather service can function without suitable meteorological instruments. Some of the instruments in use at the first order stations have undergone no change in more than twenty-five years, because they are fulfilling every demand. Others have been improved from time to time and new instruments of various kinds have been devised. Professor Marvin, the Chief of the Weather Bureau and one of the foremost authorities on meteorological instruments, has designed a weekly recording rain gage. This instrument can be placed in an inaccessible or remote place, and a continuous precipitation record maintained by making weekly trips to the gage to change the record sheet and empty the water. Many efforts have been made to devise a gage that will secure a true catchment of snowfall in windy weather. It is the hope of meteorologists that this problem will be solved. Through experiments in the wind tunnels of the Bureau of Standards it has been found that the Robinson four-cup anemometer records too much wind, and stations are to be supplied with a three-cup pattern that has been selected from a number that have been tested. The Instrument Division has recently brought out a combined thermograph and telethermoscope. The thermograph is operated in the office instead of in the shelter outside, but it records the out-of-door temperature. Unfortunately this can not be operated at a distance of more than 65 feet from the outside mechanism.

Seismological investigations and the study of volcanos have been transferred to the Coast and Geodetic Survey and the Geological Survey, respectively, but solar radiation investigations are being continued by the Weather Bureau. Observations are made at Washington, D. C., Madison, Wis., Lincoln, Neb., and Santa Fe, N. M. These studies are very helpful to illuminating engineers. The Owen's dust counter is used to make a survey of the dust content of the atmosphere, employing airplanes for the observations aloft. It has been found that the dust content is greater near the surface than aloft, and that there are more dust particles over industrial centers and cities like London than in places similar to Washington. In dust count determinations made in October and November, 1923, at Washington, the number of dust particles per cubic centimeter on cloudy mornings varied from 480 at the surface to 33 at 10,000 feet elevation. Studies to determine the effect of weather conditions on plant growth are being constantly made by the Division of Agricultural Meteorology. This division supervises the special crop region services and issues on Wednesdays both state and national weather-crop bulletins. In his effort to secure all publications pertaining to meteorology and allied sciences the librarian has a collection of some 40,000 books and pamphlets, the most complete meteorological library in existence. As a source of further information the Bureau issues the "Monthly Weather Review". This publication is the clearing house for the exchange of ideas and facts concerning weather and climate. Contributions are offered by both American and foreign writers, many of them being devoted to theoretical meteorology.

Floods take a heavy toll in damage to property and hindrance to business. The forecaster cannot prevent the floods, but he can issue warnings of flood stages so that the people along the rivers may save their property and adjust their business affairs. The forecasting of flood stages is a complex problem, because of the uneven distribution of rainfall, the melting of snow, the condition of the soil as it affects runoff, the breaking of levees, and the discharge from tributary streams. Yet, river forecasts are the most accurate made. The prin-

cipal rivers are divided into districts, each under a Weather Bureau official and with its gaging and rainfall stations. The St. Louis district is the largest. At the time of the Illinois River flood in 1922 the St. Louis official, on April 16th, predicted a crest stage of 25.1 feet for Beardstown. Four days later the crest stage, 25.1 feet, occurred, exceeding all previous records for high water at this place. As funds permit, the river and flood service will be extended gradually to many of the smaller streams.

The meteorologist, having secured a fair knowledge of the conditions at the surface, desired to learn more about the upper air. Although kite flying was begun in 1898, it is only in comparatively recent years that aerological investigations have been conducted in a systematic manner. Aerological stations are now in operation in Indiana, Nebraska, North Dakota, Oklahoma, South Carolina, and Texas. The Army and Navy maintain similar stations in various parts of the country and the Weather Bureau and these services exchange observations and reports. When weather conditions permit, kites are sent aloft carrying instruments that give continuous record of pressure, temperature, humidity, and wind. At times as many as five or six kites are flown in tandem. When records at higher elevations are desired, sounding balloons are sometimes sent up daily for a period of days, with a recording instrument attached. These balloons are inflated with only sufficient gas to cause them to burst at high elevations. A parachute allows the recording mechanism to reach the ground in safety; a note attached instructs the finder to return the instrument to a designated Weather Bureau station. Sounding balloons have reached altitudes of more than 19 miles, approximately three times the height attained by Major Schroeder in an airplane. One of the newer developments is the pilot balloon. These small balloons do not carry instruments. They are liberated at 4 p. m., 75th meridian time, at the aerological station and at certain Weather Bureau offices. At some places flights are made at 8 a. m. also. Having determined the ascentional rate by the double theodolite method, the balloons are now observed through a single

instrument. The altitude and azimuth are noted every minute until the balloon is lost to vision. Computations are then made of the wind velocity and direction at various altitudes, and they are telegraphed to the district forecasters. These, of course, are essential in the preparation of aviation forecasts, and are helpful with the surface forecasts because the wind aloft has considerable bearing on surface conditions. There is much to learn about the upper air, and it is likely that improved methods will be developed for its survey.

Without doubt the activity of the Weather Bureau in which the business man and the general public are most interested is the issuance of weather forecasts. To the mariner, the farmer, and the shipper of perishables the forecasts are indispensable, and they even become a part of the preparations for picnics and automobile trips. The money saved by cold wave warnings in the Chicago forecast district in a single season more than equalled the cost of operating the entire Weather Bureau a year. For more than fifty years the forecasts have been made from synoptic charts. Probably there has been some improvement; at least the percentage of accuracy for the service averages 88.4 per cent. Radio has stepped in and greatly aided that very important work of the forecaster, where lives and property are at stake, the predicting of those tropical storms known as West Indian hurricanes. Many of these disturbances develop near the Cape Verde Islands, drift westward with the trade winds, ever seeking a place to break through the Azores high pressure belt. Reaching the western side of this belt, where the pressure is lower, they recurve to the northeastward, passing up the Atlantic coast or entering the Gulf of Mexico. The storms are hundreds of miles in extent, great whirls with wind velocities as high as 120 to 140 miles per hour, but the velocity of translation of the whole storm is sometimes quite slow. Before the days of radio they were sometimes "lost" over the ocean, the land stations showing little evidence of the location. Now observations are taken regularly on all U. S. Shipping Board vessels and many others. These are radioed to the Weather Bureau at Washington, giving the ship's position.

Weather maps are then prepared for the ocean as well as for the land, and forecasts of the location, extent, and probable movement of the hurricane are broadcast to the vessels at sea. The navigators can then set their courses to avoid the worst of the storm.

Among some of the newer forecast developments mention should be made of the harvest-weather, fire-weather, and fruit-frost service. The first is for the farmer; the second for the forest ranger, the forecaster warning him when conditions are favorable for timber fires. The Bureau has eight meteorologists and observers on duty in the citrus orchards of southern California. Thermometers and thermographs are placed at numerous places among the trees. These are read frequently during the night, and when the meteorologist on duty gives the word the oil heaters are lighted. It is not a smudging proposition. The temperature of the air is actually raised that number of degrees that will bring it above the frost danger line. Orchard temperatures have been raised as much as eight or ten degrees by this method. Later in the season these men go to the apple orchards of Idaho, Oregon, and Washington.

What of the future? Our Bureau does not, ordinarily, attempt to make forecasts for more than 36 or 48 hours, although the Washington office prepares a weekly forecast based on telegraphic reports from the entire northern hemisphere, Siberia excepted. The Canadian Government is establishing radio weather stations near the Arctic Ocean, and it is hoped that a similar station will be installed at Point Barrow, Alaska. These will be very helpful to the forecaster. But will it ever be possible to prepare seasonal forecasts? Scientists are studying periodicities and the relation of sunspot phenomena to weather recurrences. It has been found that certain seasonal pressure conditions over the Pacific Ocean influence the temperature of the water of the Japan current, and this in due time affects the air temperature along the California coast. Professor Marvin, the Chief of the Weather Bureau, refuses to say that long range or seasonal forcasts will not some day be made. This is one of the tasks of the meteorologist of the future, and is one of the most important problems of the weather man.

INSECT HAZARD TO ILLINOIS FIELD CROPS

W. P. Flint, Natural History Survey, Urbana

In insuring a residence or other building against fire, the company selling the insurance will charge a certain rate based on data which they have compiled on the occurrence of fires in other buildings similarly located, and showing the approximate fire hazard of the property in question. This hazard varies with the location of the property, the fire fighting apparatus of the town in which it is located, the construction of the building, the water supply, and other factors. These tables compiled by the insurance companies enable them to put a valuation on all of these factors, and to tell with a fair degree of accuracy what are the chances of the building burning during a given period of time.

The paper here presented is an attempt to show in somewhat the same way the insect hazard to which the field crops most generally grown in Illinois are subjected during the growing season. The data available do not always permit stating this hazard as accurately as desired, but are sufficient to give an approximation of the hazard. The following tables are compiled from data gathered by the State Entomologist's office covering a period of over sixty years, and by the Entomological Section of the Natural History Survey, which during the last five years has conducted the work formerly carried on by the State Entomologist; also from publications of the Experiment Stations in adjoining states where agricultural conditions are much the same as in Illinois. The insects listed are those which are sufficiently abundant from year to year to cause commercial damage to Illinois field crops. In listing the insect hazard, the state was divided into three sections, Northern, Central, and Southern, the division being based in part on the type of agriculture, and in part on the occurrence or abundance of the different species of insects. With some crops, the insect hazard does not change greatly from north to south, or on different types of soil. Other insects, however, vary greatly in their abundance and the amount of injury which they cause in the different sections of the state. Some are of no importance, or are scarcely ever

seen in Northern Illinois, while they are very abundant in the south, and vice versa.

The attempt is made to estimate the hazard from a given insect for an average year under average farm conditions. The hazard is based not on what would occur if no attempt was made to combat insects, nor on what does occur where the best known methods for insect control are put in practice. The stage of the plant when the insect attacks occurs, the point of attack, and duration of feeding have been taken into account. In some cases the damage resulting from diseases and fungi which gain access to the plant where the insect has fed is greater than the direct injury by the insect. Such damage is ascribed to the insect as being primarily responsible.

While no claims are made for the accuracy of the following tables, they are the best that the writer could compile from the data available. It is hoped that any one interested in this subject will help in making these tables more accurate by criticism of any statements which do not seem correct. Such tables are of importance to the farmer or land owner, not only because they attempt to show the insect hazard to a given crop for a normal year, but because if the type of land is such that any one particular species is known to be abundant, it will help him to determine the amount of risk he is running from that species. If in a certain year a certain insect is known to be unusually abundant, he may determine before hand the chance of securing a good crop under conditions of heavy infestation by this insect.

The importance of an insect may change greatly from one year to another, or the insect hazard may increase with the introduction of some new pest. Similar tables for cotton compiled thirty years ago would not have mentioned the Cotton Boll Weevil, where at present the hazard from this insect alone amounts to approximately fifty percent. It is quite likely that in ten or fifteen years, a similar condition may exist in regard to the Illinois corn crop in connection with the chance of injury by the European Corn Borer.

INSECT HAZARD TO CORN.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Northern Corn Root Worm	1.	1.	.5
White Grubs	1.5	.5	.2
Wire Worms	.1	.1	.1
Chinch-bug	.05	1.	3.
Corn Ear Worm	1.5	2.	2.5
Southern Corn Root Worm	.2	.5	1.
Corn Root Aphis	.5	.5	.5
Army Worm	.01	.01	.01
Grasshoppers	.02	.02	.02
Cutworms	1.	1.	1.
Corn Seed Maggot	.2	.1	.05
Common Stalk Borer	.02	.01	.02
Sod Web Worms	.1	.05	.05
Bill Bugs	.05	.05	.1
Morning Glory Flea Beetles	.05	.05	.1
Corn Seed Beetle	.01	.....	.....
Clover Root Worm	.....	.05	.01
Pale Striped Flea Beetle	.5	.2	.1
Other Insects	1.	1.	1.5
Total	7.61	8.14	10.86

WHEAT

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Hessian Fly	4.5	5.	5.
Chinch-bugs	.....	.3	1.
Wheat Joint Worm	1.	1.	1.
Wheat Stem Maggot	.5	.5	.5
Wire Worms	.05	.02	.02
Grasshoppers	.1	.1	.1
Army Worms	.05	.05	.05
Wheat Head Midge	.05	.....	.....
Bill Bugs	.05	.05	.05
Wheat Head Army Worm	.002	.....	.....
English Grain Louse	.01	.1	.1
Green Bug	.05	.05	.05
White Grub	.5	.1	.1
Angoumois Grain Moth	...	.02	.02
Southern Corn Root Worm	.05	.1	.1
Other Insects	1.5	1.5	1.5
Total	8.91	8.89	9.59

RYE

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Chinch-bug	.....	.2	.3
Hessian Fly	.05	.05	.05
Army Worm	1.	1.	1.
Grasshoppers	.2	.2	.2
Wheat Stem Maggot	.05	.05	.05
English Grain Louse	.01	.1	.1
Green Bug	.2	.5	.5
Other insects	2.	2.5	2.5
Total	3.51	4.60	4.70

OATS.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Chinch-bug	.001	.3	.5
Army Worm	1.	1.	1.
Green Bug	.5	1.	1.
Grasshoppers	.05	.05	.05
Common Stalk Borer	.001	.001	.001
English Grain Louse	1.	1.	1.
Oat Thrips	.2	.2	.2
Other Insects	1.5	2.	2.
Total	4.261	5.35	5.551

BARLEY.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Chinch-bug	.05	1.	.....
Army Worm	.5	.5	.....
Wheat Stem Maggot	.1	.1	.....
Hessian Fly	.1	.1	.....
English Grain Louse	.5	.5	.....
Green Bug	.2	.5	.....
Other Insects	2.	2.5	.....
Total	3.46	4.35	.....

SUDAN GRASS.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Chinch-bug	.01	1.	2.5
Grasshoppers	1.	1.0	1.0
Army Worm	.1	.1	.1
Aphis	.2	.5	.5
Other Insects	1.5	2.	2.5
Total	2.81	4.6	6.6

TIMOTHY.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Grasshoppers	1.5	1.5	2.
White Grubs	2.	2.	1.5
Cutworms	1.	1.	1.
Bill Bugs	.2	.2	.2
Wire Worms	.1	.1	.1
Leafhoppers	1.	1.	1.
Army Worms	.5	.5	.5
Capsids	.1	.1	.1
Sod Webworms	.05	.02	.02
Chinch-bugs	.....	.1	.2
Wheat Head Army Worm	.02	.01	.....
Other Insects	1.	1.	1.
Total	7.47	7.53	7.62

BLUE GRASS

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
White Grubs	3.5	3.	2.5
Cut Worms	1.	1.	1.
Grasshoppers	2.	2.	2.5
Capsids	.1	.1	.1
Wireworms	.5	.5	.5
Sod Webworms	1.	1.	1.5
Jassids	1.5	1.5	2.
Army Worms	.5	.5	.5
Other Insects	1.5	1.5	2.
Total	11.60	11.10	12.60

ALFALFA.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Sitones	.5	.5	.5
Pea Aphis	1.	1.	1.
Garden Webworms	1.5	1.5	1.5
Grasshoppers	1.5	1.5	2.
Clover Leaf Weevil	.01	.01	.01
Leafhoppers	.5	.5	.5
Cutworms	1.	1.5	2.
Clover Root Borer	.01	.01	.01
Green Clover Worms	.01	.01	.01
Alfalfa Caterpillar	.02	.02	.05
Blister Beetles	.02	.02	.02
Other Insects	1.5	1.5	2.
Total	7.57	8.07	9.60

RED CLOVER PLANT.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Clover Seed Caterpillar	.01	.01	.01
Clover Bud Weevil	5.	5.5	5.5
Clover Leaf Weevil	.5	.5	.5
Grasshopper	2.	2.	2.
Sitones	.2	.2	.2
Pea Aphis	1.5	1.5	1.5
Variegated Cutworm	.5	.5	1.
Green Clover Worm	.01	.01	.....
Clover Leaf Tyer	.01	.01	.01
Army Worm, Cutworms	1.5	1.5	1.5
Clover Root Borer	.02	.02	.02
Clover Stem Borer	.001	.005	.005
Leafhopper	.1	.1	.1
Other Insects	1.5	1.5	1.5
Total	12.85	13.36	13.84

RED CLOVER SEED.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Clover Bud Weevil	20.	20.	25.
Clover Seed Chalcid	3.	3.	3.5
Clover Seed Caterpillar	2.	2.	2.
Clover Seed Midge	2.	1.5	1.5
Other Insects	.5	.5	.5
Total	27.5	27.0	32.5

SOYBEANS.

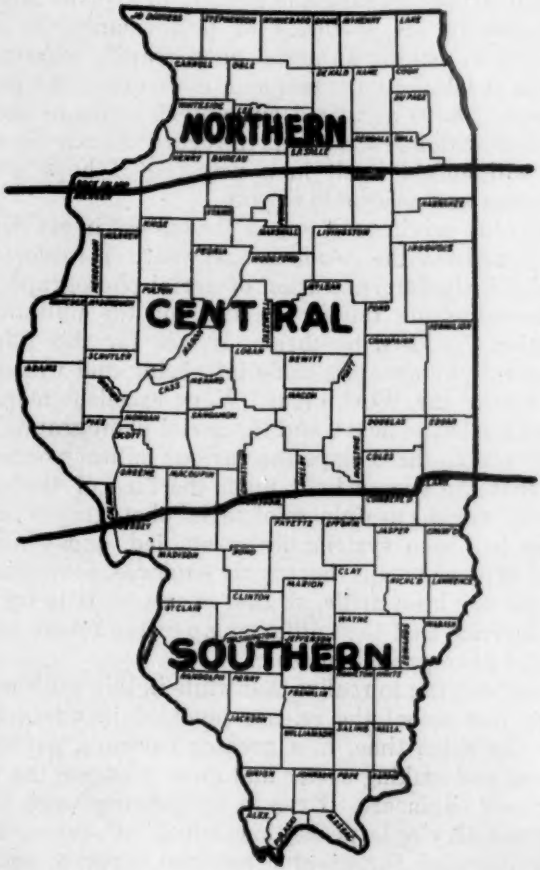
Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Sitones	.002	.002	.002
Grasshoppers	2.	2.	2.5
Green Clover Worm	.01	.01	.02
Clover Colaspis	.02	.02	.01
Other Insects	2.5	2.5	2.
Total	4.532	4.532	4.53

SWEET CLOVER.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Grasshoppers	2.	2.5	3.
Clover Stem Borer	.1	.1	.1
Pea Aphis	1.	1.	1.
Other Insects	2.5	3.	3.5
Total	5.6	6.6	7.6

POTATO.

Insect.	Percent of Damage. Northern Ill.	Central Ill.	Southern Ill.
Colorado Potato Beetle	3.	3.	3.
Potato Leafhopper	10.	10.	10.
Potato Flea, Beetle	.5	.5	1.
White Grub	1.	.5	.5
Blister Beetles	.02	.02	.02
Potato Aphis	.001	.001	.01
Wireworms	.02	.02	.02
Other Insects	.5	1.	1.
Total	15.04	15.04	14.55


NORTHERN
CENTRAL
SOUTHERN

THE MAKING OF AN AERIAL PHOTOGRAPHIC MOSAIC

Captain William D. Wheeler, A. S., Director of Photography, Air Service Technical School, Rantoul

It will be my pleasure this evening to explain to you in detail and in the sequence of performance the steps necessary in making an aerial photographic mosaic. As pictures speak the universal and, more often, the perfect language, I have arranged my lantern slides in such an order that with a few remarks in regard to each the whole story will unfold itself in a way that I hope will be interesting and enjoyable to you.

It was the privilege of one of the officers in my department to address the Academy last year. He selected as his subject the interpretation of aerial photographs and the dissemination during warfare of the military information disclosed by them. It was for this purpose that aerial photography came into being and was developed during the World War. Very excellent maps existed of the battle fields, and the aerial photographs were used to add to these maps the various military organizations that the enemy built upon the face of the earth. Since the war the usefulness of aerial photographs in map making has been systematically studied, and while the subject is by no means thoroughly explored, commendable progress has been made, so that even now it is my personal forecast that the military map of the future will be an aerial photographic mosaic.

It is gratifying to realize that while in this work we are keeping abreast of the science involved in warfare, we are at the same time, in a greater measure, perfecting mapping and making easier and more accurate the work of our civil engineers. Even in the practice work of the Army Air Service in peace time, which, of course, is primarily intended for greater national security and the maintenance of international peace, we are producing a product useful to the map making agencies of the Government. We are turning over to them copies of these practice aerial photographs and they are using them in making better maps. It may astonish many of you to know that our own beloved country is very much un-

FIG. I.

mapped. At present the topographic quadrangle sheets made by the United States Geological Survey cover scarcely 40% of the United States proper. Many of the maps embraced in this percentage were made many years ago and badly need revision. Our Army Air Service while carrying out its photographic training problem has engaged in the photographing of areas of which maps were being made, and in this way it has effectively cooperated with the Corps of Engineers of the Army, the United States Geological Survey, the United States Coast and Geodetic Survey and similar federal mapping agencies, and it has been demonstrated that with the use of aerial photographs better maps can be produced more quickly and more cheaply than without these pictures.

However, all these thoughts are really relevant to the subject of the use of aerial photography in map making, upon which a book might profitably be written. As I am allotted only an hour this evening in which to tell you how an aerial photographic mosaic is made, I must address myself directly to my theme.

When a photograph is taken with a camera so mounted in an airplane that it points directly at the earth, the result is called a vertical aerial photograph. This is such a picture (Fig. 1). You will observe that this photographic record is really a map giving in exact and exquisite detail the objects visible on the earth's surface, such as a river and its tributaries, streets, roads, railway lines, houses, fields, woods, etc. Incidentally, this particular photograph was made by Army Air Service officers at an altitude of over six miles, the greatest height at which an aerial photograph has ever been made by man. It embraces an area of nineteen square miles, and includes practically all the city of Dayton, Ohio, and its environs. Although it was taken in May, the temperature at the height taken was 62½ degrees below zero, Fahrenheit.

The scale of this picture is small, and the altitude at which it was made was so great that it was uncomfortable for personnel. The photograph was really an altitude test rather than a sample of a common vertical photograph. It is usually our practice to fly at about one-third of this height. When this is done the scale of the ground

details is much larger, but the area included in the photograph is considerably smaller. However, if it be desired to cover as large an area as that embraced in the picture I am showing you, or even a larger area, recourse must be had to the making of what is known as an aerial photographic mosaic; that is, a number of vertical photographs are so taken that they can be joined together and will form a composite picture of the entire area. In order to understand clearly the necessary steps in the making of a mosaic, we must consider the conditions under which any individual vertical picture is made.

The size of the area included in a vertical photograph depends upon:

(1) The altitude of the camera at the moment of exposure;

(2) The focal length of the lens used; and

(3) The size of the film or plate used.

From these factors each side of the ground rectangle included in the photograph can be computed, also the area of the rectangle, and the scale of the photograph. The scale of the ground objects can be regulated by selecting the height flown and the focal length of the lens used. The closer the camera is to the ground, the larger will be the images of ground objects in the photograph. At the same height the scale of a photograph taken with a longer focal length lens will be greater than that obtained with a shorter focal length lens. Thus, at the same altitude the photographic image of an object photographed with a lens of 24 inches in focal length will be exactly twice the size of the image of the same object in a photograph taken with a lens of 12 inches in focal length.

The method of making ground area and similar computations will be obvious from this diagram (Fig. II) which represents (very much out of proportion, of course) a camera suspended in the air and pointed directly at the earth, with its longitudinal axis perpendicular to the plane of the earth's surface.

"O" is the lens. "OA" and "OB", the angle of view, or inclusion, of the lens. "AB" or "L" is the distance on the ground, and "ab" or "l", the image of that distance on the plate or film in the camera. From the plan view shown by the illustration it will be seen that the

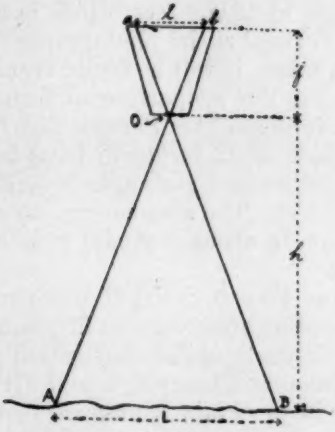


FIG. II.

distance on the ground "AB" and the sides of the angle of inclusion "OA" and "OB" form a triangle. Similarly, in the camera the image of the ground distance on the plate or film "ab" or "l", and the boundaries of the rays of light from the lens to the plate or film "Oa", "Ob", form a triangle. As these two triangles are similar, their respective sides and altitudes are proportional one to the other. It, therefore, follows, for instance, that the image of the ground distance on the plate is to the actual ground distance as the altitude of the smaller triangle (which is the focal length of the lens and indicated as "f") is to the altitude of the larger triangle (which is the height of the camera from the ground and designated as "h"). In other words:

$$l : L :: f : h$$

or

$$\frac{l}{L} = \frac{f}{h}.$$

Letting "s" represent the scale of the photograph, we find that:

$$s = \frac{l}{L} = \frac{f}{h}.$$

At an altitude of 10,000 feet, which is a common altitude at which vertical aerial photographs for the making of mosaics are taken, it will be found from computations made according to this proportion, or formula, that when using the standard size Air Service film of 18x24 centimeters and a lens of 12 inches in focal length, that the short side of the ground rectangle is 5,833 feet and the long side, 7,500 feet. The area covered by a single photograph, therefore, is about one mile wide and one and a half miles long.

Let us suppose that we desire to make an aerial photographic mosaic of an area of about fifty square miles, and let us take as an example for illustration purposes such an area surrounding Champaign and Urbana, Illinois. Our first step is to obtain a map of some kind of the region for the use of the pilot or aviator in identifying the area and directing the flight. The quadrangle sheets issued by the United States Geological Survey are popular maps for this purpose. When they are not available we obtain any map that we can of the scale of about one inch to the mile. Here is a portion of a Geological Survey map known as the Urbana, Illinois, quadrangle sheet, including the area we have selected. We have outlined the area and drawn our proposed lines of flight. (Fig. III.) Our problem is to fly back and forth across this area taking photographs in both directions and making strips of pictures that will slightly overlap, and also make certain that the side of each strip will overlap the adjacent one. The necessary overlap is a margin of safety which insures that there will not be gaps between pictures. In the final assembly of the mosaic the individual photographs are cut so that they will exactly fit together.

The overlap used is at least one-third of the area on the ground included in each photograph. Allowing for this the net ground area included in each photograph can be calculated readily from the formula, and it can be determined how many separate exposures will be required to cover the total area to be included in the mosaic.

If the width of the area included by a single photograph has been computed and the amount of overlap has been decided, it is possible to plot on one side of the boundary of the area to be covered by the mosaic, the

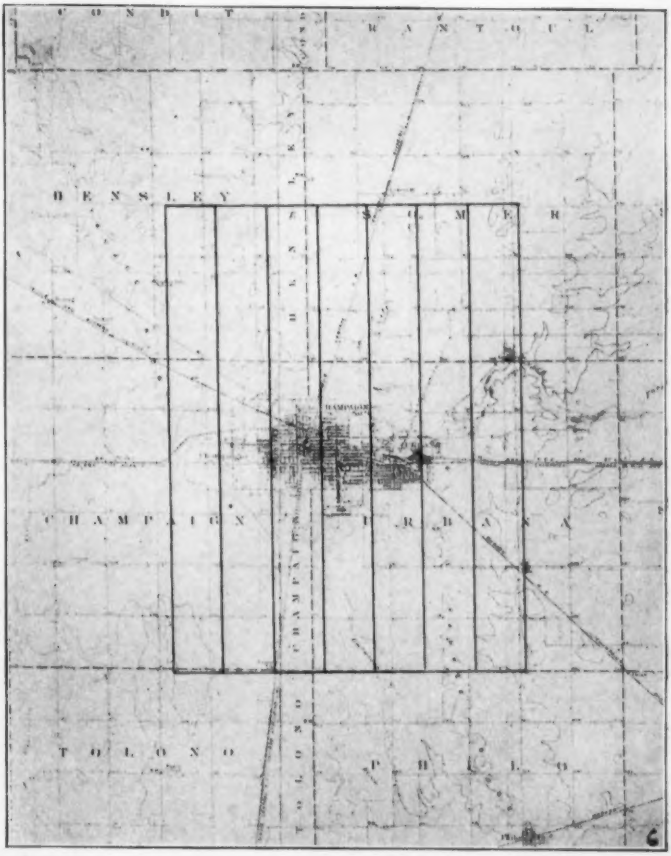

CONDIT
RANTOUL
BENSLEY
SOMER
CHAMPAIGN
URBANA
TOLONO
PHILO

FIG. III.

points at which the lines of flight should begin. When this has been done and the number of individual photographs necessary to cover the area has been determined, it is necessary, as an additional preparation for the mission, to know at the altitude selected how often a photograph must be taken so that the amount of overlap decided upon will be obtained. The photographs are taken with the width of the film parallel to the line of flight. If a one-third overlap be decided upon, an exposure must be made every time two-thirds of the width of the ground space is flown. The total width of the ground space can be calculated readily in the manner already explained, and as the speed of the airplane in still air is known and can be reduced, if necessary, to feet per second, it will be found that the interval in seconds between each exposure is equal to two-thirds of the width of the ground area divided by the speed of the airplane in feet per second.

This slide (Fig. IV) shows graphically the line of flight, the points, or intervals, at which the exposures must be made, and the amount of ground area and overlap covered by each successive view.

All the necessary calculations preparatory to a photographic mission of this sort have been embodied in a table of information which gives for the standard Air Service size of film, according to the focal length of the lens, the sides of the ground rectangle covered at different altitudes, the scale of the photographs and the exposure intervals for three speeds, namely eighty-five, one hundred and one hundred and ten miles an hour.

The air above us does not pass in a solid column in the direction of the prevailing surface wind, as many may think, but there are strata of currents of varying thicknesses that often move in different directions and at different velocities from one another. For instance, the surface wind from the west of a velocity of fifteen miles an hour may extend upward only 500 feet, and above that may be another stratum, of for instance 1000 feet in thickness, moving at a different velocity in an opposite direction. While it is true that we make wind-aloft readings for aeronautical and weather data which give us the direction and velocity of air currents up to

the height at which the test balloon sent up for this purpose disappears, air conditions may rapidly change and the latest report may have become stale and really worthless before we actually begin photographic work at the altitude selected. Therefore, while the interval of exposure may be calculated for the speed of the plane when flying in still air, allowance must be made for the meteorological conditions, such as wind-opposition, that may be encountered at the altitude selected. As such conditions are unknown on the ground save for wind-aloft reports which may have become stale, ground calculations may be valuless at the time photographic work is begun.

In order to take into proper account these fluctuating factors, use is made of a view finder. This is a metal cone with a lens at one end and a ruled ground glass in the focal plane. The nose of the finder is rounded and fits into a socket mounted in a hole in the bottom of the plane close to the photographer's seat. The interchangeable ground glass screens are ruled for lenses of the different focal lengths used in the Air Service. The horizontal lines are designed for the common amount of overlap given, namely, 60%. The exposure interval is obtained readily with this instrument when the desired altitude is reached by the photographer's measuring the time required for the image of a ground object on the screen to pass from one horizontal line to the other.

We will suppose that we wish to make our mosaic with what is known as Type K-3 aerial camera. This employs a lens of 12 inches in focal length, which is the focal length of the lens that we decided to use when our flight map was prepared. Here is a picture (Fig. V) of this camera. This is the camera (pointing) with film magazine attached. This is an extra magazine. This is the suspension (pointing) in which the camera is mounted in the airplane. These are electrical cables which connect the storage battery with the camera. You will note that here is the motor which drives this automatic instrument. Before reaching the motor, the current passes through this device called an "intervalometer". This is an automatic switch which operates the camera at any desired frequency required by the interval of exposure. The

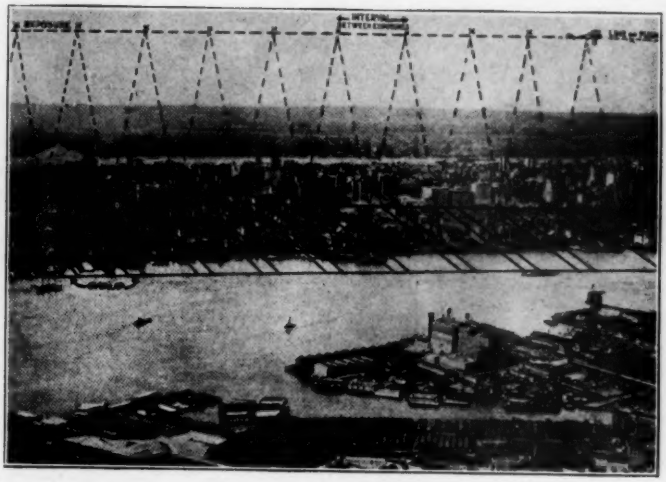


FIG. IV.

FIG. V.

camera suspension is so arranged that the points of suspension rest in soft sponge rubber so that they take up the vibration of the airplane and eliminate the blur which would otherwise be apparent in the picture. The suspension is so constructed that when the camera is mounted in it, it is virtually on a universal joint and may be moved to any angle and in any direction necessary to keep its longitudinal axis perpendicular to the surface of the earth.

Having selected our photographic apparatus we next load the magazine in much the same manner as a small camera employing film on spools. However, the size of a roll of aerial film differs greatly from that used in a hand camera. A roll of the standard aerial film is approximately 10 inches wide and 75 feet long. To both ends safety paper is attached after the fashion of spools of film for small hand cameras.

With the camera loaded, we are ready to install our photographic apparatus in the airplane. The airplane generally used in photographic mosaic work is of the De Haviland type known officially as "Type DH4BP1". It is equipped with the famous Liberty engine of 400 horse-power and is similar to the other De Haviland planes now used in the Air Service which are so popular for many common purposes. The photo ship, however, differs from the usual service type of DH in that the cowling of the rear cockpit, instead of being built up to provide for a machine gun mount, is cut away and padded. This cockpit has also been enlarged and reinforced so as to provide sufficient room for a camera and a photographer. There is an aperture in the bottom of the fuselage through which the photograph is taken; also a storage battery that supplies the motive power. The suspension is clamped to cross pieces attached to wooden uprights. The uprights in turn are fastened to the vertical ribs of the airplane body.

Success in aerial photography, aside from the necessity for suitable airplane and good photographic apparatus, depends upon the skill of the pilot and the skill of the photographer, and close teamwork between them. The pilot must keep a straight course, flying exactly down the lines of flight indicated on the map, and he must keep

a constant altitude. Just before each exposure a small electric light, regulated by the camera mechanism, lights in his cockpit as a signal to hold the airplane as level as possible at the moment of exposure, which is timed to be five seconds later. If one wing of the plane is higher than the other while the photograph is being taken a distorted result is obtained. If the airplane is in a slight climb or a dive, not only would a distorted wedge-shaped picture result, but the exact ground area which that photograph should cover will be missed, as this diagram shows (Fig. VI).

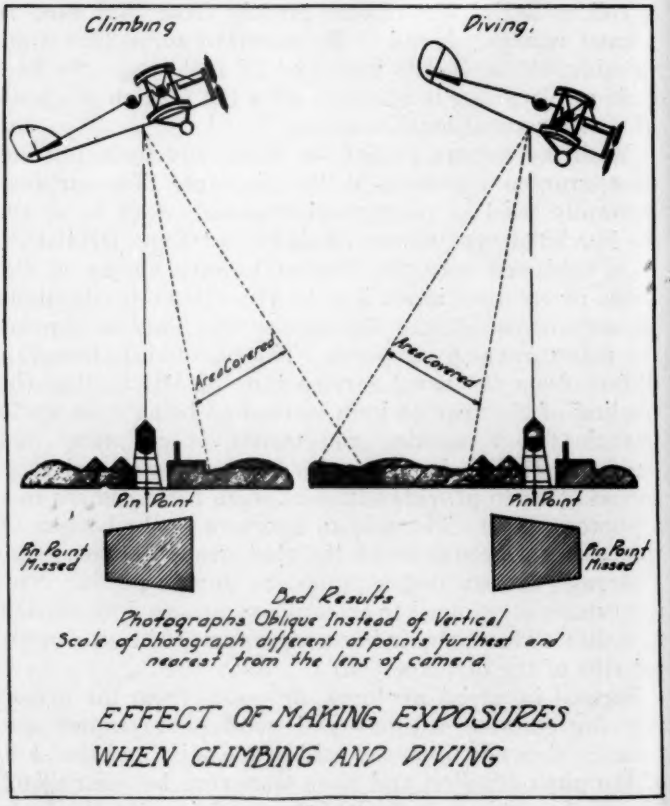


FIG. VI.

During photographic operations the photographer has much to occupy his mind. When the desired altitude is reached the pilot flies straight and level in the direction of the first strip to be made so that the photographer can find, with the use of his view finder, the correct interval of exposure and set his intervalometer accordingly. If the wind is from the side, the nose of the plane must be pointed into it, or, as we say, the ship must be "crabbed". When the wings of the airplane make other than a right angle with the line of flight, the camera must be turned in its suspension so as to overcome the saw-tooth edge which would result in the plotting of the strip of photographs if the camera were not turned to offset this yawing and thus make the photographs abut one upon the other. With the interval of exposure and the amount of crab of the plane determined, the photographer is ready to start the camera, and this he does at a signal from the pilot when over the beginning of the first strip. As the pilot, with the map in one hand, flies in a straight and level direction along the line of flight, following the course on the ground through a window in the floor of his cockpit, the camera automatically clicks off the exposures at the intervals of time regulated by the intervalometer. The photographer the while holds the camera to the vertical according to the spirit level attached thereto. At the conclusion of the strip the pilot signals to cease photographing, continues considerably beyond the area, turns and flies at the selected altitude straight and level in the direction of the second strip so that the photographer may obtain the interval of exposure and amount of crab necessary for this strip. The interval and amount of crab of a small area are considered uniform for each strip in the same direction so that when these data are obtained for the first two strips in both directions they are used for the remaining strips.

Film magazines are interchangeable in the air so that in the case of a large area a number of rolls of film, each providing over a hundred exposures, may be carried on a single flight. When photographing a large area it is the practice to carry film almost to the extent of the gasoline capacity of the plane; such capacity of course depends upon the size of the tank of the airplane and

ranges from four hours and a half upward. The speed with which a mosaic is ordinarily flown is one hundred miles an hour so that a strip of one hundred photographs, each covering more than one square mile, can be made in one hour on a single roll of film.

We will assume that we have photographed the area and that we are now ready to develop the film. This is the film developing apparatus (Fig. VII). It consists of a transfer stand on which (in the darkroom of course) the film is wound from the spool around a reel and between the coils of a celluloid band called an apron. These coils are held apart by corrugated metal strips at the ends. The apron of a reel when loaded with a roll of film is secured by a retaining band. The loaded reel is then immersed into a tank of developer. This tank has a water-tight lid which can be locked on, and is also provided with a handle which permits the tank to be reversed during development in order to secure even action of the developer. The development is for a certain length of time, fixed according to the strength or degree or concentration of the developing solution, and also fixed according to the temperature thereof. At the expiration of this time the reel is rinsed in water contained in a tank similar to the developing tank, and finally transferred to a third tank of similar design, which contains the fixing bath and thence upon completion of fixation, to a fourth tank of running water. This slide (Fig. VIII) shows development in progress.

Upon completion of the final washing the film is transferred to a large wooden cylindrical drum which is revolved by electric motor, thus expediting the drying of the film. When dry, the film is wound around the original wooden spool on which it was supplied and it is kept in the original metal tube or container. It is not the practice to cut negatives apart. For their identification they are numbered at present by hand. In the near future it is expected that they will be numbered by a separate numbering device in the camera that will make an impression upon the film at the moment of exposure. In numbering film the standard type of plotting table is used. This provides a window enclosing an electric light. The negative film is wound by hand

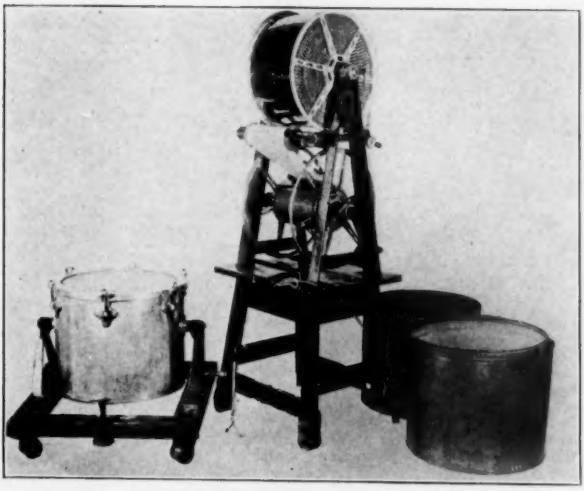


FIG. VII.

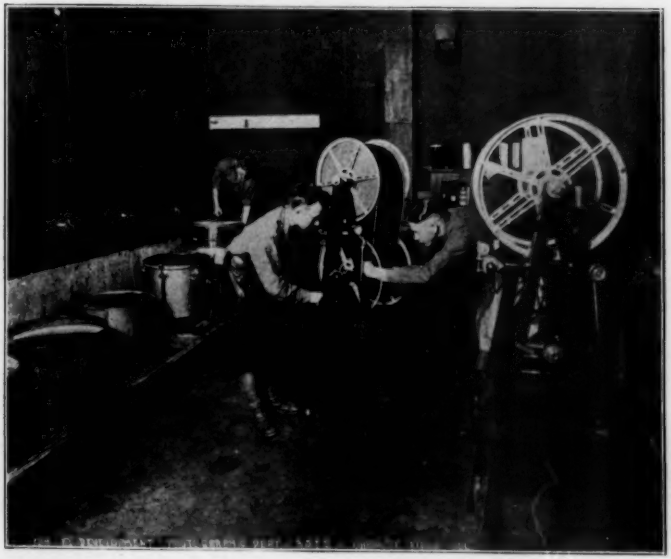


FIG. VIII.

across this window and numbered or examined at leisure. With the numbering completed, the area covered by the individual exposures are plotted on a map to scale. This is done to determine whether the area has been completely photographed. The separate plottings of the photographs are numbered, and when completed this map also serves the purpose of an index to the different exposures.

With the film numbered and plotted, the next step is the making of the positive prints, or photographs. A special form of contact printer is used, which differs from the usual type of photographic contact printer in that holders are provided for the spool of film and for a take-up spool. The film is thus rolled across the printing surface of the machine as desired. This printer has nine electric lamps controlled by separate switches so that all, or any combination of these lights, can be turned on. This permits of compensating for any uneven density in the negative by turning out a light under a too-transparent portion. As the combined candle-power of these lights is great, much heat is generated which is eliminated by a small electric blower, thus preventing the heat from cracking the ground glass diffusing screen above the lights and the plate glass top of the printer. The back of the printer has a pneumatic cushion which is found to be more satisfactory than the usual type of felt padding.

The photographic paper used in the Air Service is invariably of a glossy surface and is one of the commercial bromide or chlorobromide emulsions. The methods used in the making and finishing of the prints are essentially the same as those used by any photographer when using one of these papers. The prolonged final washing, however, is sometimes done in a special washing machine consisting of a perforated drum or holder for the prints, which is revolved by motor in a tank of running water.

The drying can be expedited by the use of a special drying machine, which consists essentially of an electrically heated drum around which an endless belt is revolved. Prints are placed upon this belt, and by the time they have been slowly conducted by the belt around

the drum they are dropped dry into a receiving receptacle.

With prints completed, we are ready to join the separate, individual photographs in order to make the composite photograph or mosaic. In this assembly the photographs are cut or torn so as to fit together, and as each is cut it is pasted to a suitable mount. In order that the composite photograph may be accurate as to scale it is necessary that the work of assembling and affixing the prints to the mount be controlled by measurements between the photographic representation of objects which will be in proportion to the distances between the actual objects on the ground. The ground distances are obtained in the form of surveyor's notes. If the area is large enough to make the curvature of the earth material, a polyconic projection is made upon the mount, and on this the stations appearing in the surveyor's notes are accurately plotted to the same scale as the photographs.

A photograph showing one or more of these stations is then pasted to the mount so that the point or station in the photograph will be exactly superposed over the station as plotted on the mount from the surveyor's notes.

The adjoining photograph is then found and is cut so that it will not only fit the first photograph but so that any stations in that picture will exactly fit over the stations plotted on the mount. The fitting together of the pictures, aside from the superposition required by control points, is not only a test of manual dexterity in cutting the pictures, but also of skill in photographic printing, because great pains must be taken that the tone of all prints match so that the completed assemblage will be of uniform color. In laying down or assembling the mosaic the exact superposition of a control point in a photograph over that plotted on the mount is effected by an ingenious device known as a mosaic control point indicator. A steel phonograph needle is suspended from an arm which may be raised and lowered. This needle is fixed on the control point plotted on the mount, and the arm of the device is then raised so that the print with adhesive applied can be placed on the mount. The control

point in question, as shown on the photograph, is placed as nearly as possible over that on the mount as indicated by the needle point of the indicator, which, after the print is placed in position, is lowered. If necessary the print is moved about until the needle point rests upon the control point, as shown in the photograph.

Adverse meteorological conditions, or lack of skillfulness of the pilot, or a combination of both, may result in differences in scale of the photographs covering an area and may require that some of the prints, in order to fit together, be of a greater or a smaller scale. This change in the scale of a print can be easily effected by a certain type of enlarging or reducing camera. This apparatus consists of a camera on a movable arm. In this camera the negative to be projected at a different scale is inserted in the focal plane of the camera and in front of a suitable light source surrounded by a reflector. The sensitive photographic paper is placed on the horizontal easel. By raising or lowering the arm holding the camera a projection to the exact scale desired may be instantly made. A variable cam in the camera arm mechanism regulates the focusing of the lens as the arm is raised or lowered so that any size projection effected by the moving of the camera in the manner stated is always in focus. In all other respects the operation of the apparatus is similar to that of any enlarging camera.

At the moment of exposure the airplane may not have been level, thus causing what is known as "tilt" in the photograph, shown by the fact that the print is not uniformly to scale over its entire surface. This tilt may be removed by use of a "restitutional printer" by projecting the negative image on an easel which may be swung at any angle. Three or more points are selected in the negative to be restituted, and the ground distances between those points are plotted to the desired scale on a sheet of drawing paper attached to the easel. In projecting the negative images of these points the easel is moved until each plotted point on the paper coincides with each corresponding negative image of it. A sheet of photographic paper is then substituted for the drawing paper. The exposure and subsequent operations with respect to

photographic paper are the same as those employed in enlarging.

The pasting together of the individual aerial photographs, with or without correction, as explained, completes our mosaic.

As the reduction required in lantern slide making prevents me from giving you an adequate close-up picture of our mosaic, it here seems opportune to extend a cordial invitation, on behalf of the Commandant of the Air Service Technical School, to those within the reach of my voice to visit Chanute Field, especially the Department of Photography, where I will take great pleasure in showing you the original copies of photographic mosaics. I regret that limitations in lantern slide making prevent me from bringing you adequate pictures of them.

This naturally gives rise to the question as to how we circulate mosaics. The original mosaics are too large and cumbersome for this purpose and we, therefore, reproduce them photographically in sections. To do this we employ a large copying camera which takes a photograph twenty-four inches square. The mosaic is attached to an easel which permits the picture to be raised to any height and moved back and forth. The process of copying is complementary to that of mosaic making. In this case, the camera remains stationary, and in the form of a mosaic we "move the earth" so to speak back and forth, at the same time so photographing it in sections that they may be joined together easily and accurately by anyone. The large size picture made by this camera permits us to cover a large mosaic in a few sections.

SOME WILD MEN OF BORNEO

JOHN STANSFIELD, UNIVERSITY OF ILLINOIS

The expression "wild man of Borneo" is known to every child where the English language is spoken. The origin of the expression is unknown. It may possibly refer to the "orang-outang", one of the large apes, which lives in the jungles of Borneo. However, it is one of the mildest of apes and makes a docile pet. It reaches a height of three and a half feet. It is called "mias" by the natives. The Malay words "orang-hutan" mean "man of the jungle," and doubtless the white man's name for this ape is a corruption of these Malay words.

About a century ago the coasts of Borneo, Northern Borneo especially, were infested by pirates, Dyaks, who sallied forth in great canoes holding 30 to 40 men, which swooped down on passing trading scows, murdering and robbing their owners and occupants. Perhaps these pirates were the original "wild men of Borneo".

The pirates along the northern coast have been converted to other activities by the two Brooke's, successive Rajas of Sarawak, the third of this line having charge of that country now. The authority of these rajas has been gradually extended along the coast and to some extent inland. But the farther one goes from the coast inland the more tenuous does the white man's authority become, and the native follows more and more the natural habits of primitive man. To him might is right, and power to take is all the excuse needed by him for the acquisition of anything he wants, including in many cases human heads. The spread of the white man's authority may be said to have driven head-hunting habits farther and farther back from the coast, and they would be eradicated completely if the population were dense enough to furnish a continuous system of communications. The isolation and occasional occurrence of the communities of the interior make for a continuance of the primitive conditions with which head-hunting is associated.

Borneo, one of the large islands of the tropics, 800 miles in maximum length from northeast to southwest and 600 miles in maximum width, is subject to the heavy

tropical rains of the equatorial belt, and is covered with dense jungle from the tops of the mountains to the coast, except where a few people have cleared the jungle along the banks of the large streams or along the fringe of the coast.

The larger part of the island is a colony of Holland. The northeastern part is owned and governed by the British North Borneo Company, Sarawak is owned and governed by Raja Brooke, the small island of Labuan off the north coast is a British Crown Colony, and Brunei, near the mouth of the Limbang river on the northern coast, is governed by the native sultan of Brunei who enjoys British protection.

The population of Borneo, in contrast to that of Java, is very small, and is chiefly congregated as a thin fringe around or near the coasts. These people include Malays, Kadayans (a group of Malays), Chinese, Dyaks and a handful of whites.

Apart from the whites the Chinese include, in addition to the coolie class, the highest representation of civilization in the island. Some of them are highly educated and have charge of a good part of the commerce of the island, which involves the collection and sale of the natural and agricultural products of the island and the importation of foreign goods, chiefly cottons, in exchange. Their activities also include the ownership and operation of steamship lines.

The Malays, being Mohammedans, also possess a marked civilization. The more highly respected among them are the older men who have made the pilgrimage to Mecca and so earned the title of "haji". The savings of a life-time are needed for such a trip, so the "haji" as a rule gains only the respect of his fellows, plus the spiritual progress which comes from the completion of the requirements of one's faith. The Malays live in villages on stilts which are called "campongs". They are generally built close to a stream so that the canoe can be tied to the front door-post and the refuse from the house may fall into the river and be carried away by it.

The Malays are traders in a smaller way than the Chinese and move by canoe, carrying their wares about

from village to village. They also follow agriculture, growing their needed supplies of rice, and also carry on fishing to a considerable extent, this supplying the other important part of their diet. To them the pig is unclean and other meat is rarely consumed except on festal occasions. There are craftsmen of many arts among the Malays, some of them being quite skilled. Large plantations and occasional mines are not numerous and are controlled by whites or the Chinese merchants. The labor is performed by Malays or Chinese.

The Dyaks are the older aboriginees of the island and are divisible into many different groups or tribes, often using separate languages or dialects. The dialects of related tribes in distinct river valleys are often sufciently different to make inter-communication incomplete.

The Dyaks are a lighter brown color than the Malays and they speak a language which is quite different from Malay. Five feet five inches is the average height of the full grown male. They are often strikingly handsome and as a rule show a superb muscular development. Those who know the Dyaks often refer to them as "nature's gentlemen". They live on rice and the product of the chase—wild deer, pig and smaller animals and birds. Hunting is done in part with a muzzle-loading musket, which is discharged only at very close quarters, when the outcome is a certainty, and in part by many ingenious traps. Some of the tribes which have had least contact with civilization still use the blow-pipe and poisoned darts in hunting small birds and animals. The blow-pipe is a tube 6 to 7 feet long, and the dart is blown suddenly from it and carries its silent and rapid death to a distance of 150 feet. The pig is not unclean to the Dyaks, who use it for food. Jungle products, resin, wild rubber and so forth, are sought by the Malays and Dyaks. The latter are more at home in this work than the former, though Malays thorougly habituated to the jungle life are excellent men for the work.

Travel in the island is chiefly by means of canoes on the rivers, which are the main highways. The mouths of the large rivers are visited from time to time by steam

or gasoline launches of shallow enough draft to pass over the bar which blocks the channel of each stream some miles off the coast. The lower parts of the streams run through swamps of mangroves and nipa palms. The latter tree provides a hundred and one things to the thrifty native. Cocoanut groves are common along the shores and river banks near to the villages. Some cocoanut trees growing in the interior of the island by way of experiment do not bear fruit.

The campongs of the Malays are separated from each other, and as one passes inland from the coast the campongs become farther apart and are occupied by Dyaks or others of the aboriginee tribes. Around the campongs are clearings which are used for growing rice. The method adopted in rice growing is uniform with that followed in other countries. Where the rice fields are flat the desired amount of the rainfall is retained by means of small walls of mud a foot or so in height. The water is run off by knocking openings in these walls. In the case of hilly ground the more industrious may construct terraces with the object of retaining water.

In the north-eastern part of Sarawak, visited by the writer, the Malay coastal fringe is followed by the Murut tribe which is regarded as distinct from the Dyaks in language and in some customs. The population is here so thin that the same land is only used for 4 to 6 years and then a move is made to some other place a short distance away. So terracing is not practised under these conditions. The jungle is cut and the trees burned after drying a few days. The thicker branches and trunks remain unburned and are left to cumber the ground. The Muruts then sow the rice in the following manner. A man takes a long shaft of hardwood with a blunt conical point at each end, and with this punches holes 1 inch to 2 inches in depth in the loose burnt soil. His wife follows behind and drops a few grains of rice into each hole. The farm receives no more attention until the rice heads out, from which time on it is constantly attacked by large flocks of small birds, called "pipit" by the natives. All members of the household spend the day from before sun-up until after sun-down in small huts on stilts scattered through the hilly farm. From these in many

directions run strings which carry various devices for rattling or frightening the birds by means of sudden flashes of reflected sunlight. Added to these are constant monotonous shouts from the throats of the Muruts which all help to save the crop for human food. When ripe the rice is gathered by the men who strip the grain by hand from the straw which is left standing, putting the grain into a huge plaited grass basket carried on the backs of their wives. The only other grain grown by the Muruts is maize—the variety known as field corn. The kitchen garden, or the rice field near the house often has a few cucumber vines.

The Muruts also live in houses built above ground, the floor being usually about six feet above ground. In some places the space beneath the house is enclosed by a bamboo fence and serves as a pig-sty. All refuse from the house above drops through the flooring of bamboo with its many apertures. Near the coast the Murut families live in separate houses, but in passing to the interior danger from enemies becomes greater because the location is farther removed from the reach of the white rulers, and the families of one village unite in building one large community house. Each family constructs its own portion of the roof and so the number of families in such a house may be counted by the number of divisions in the roof. As many as twenty-eight families have been found living under one roof. The long house is divided into two equal portions by a partition running vertically down the center. On one side is an open corridor which is used by all, and the other side is broken into rooms by a number of walls, each room being occupied by a family.

The clothing of the Muruts is scanty and their habits not cleanly. Many of them suffer from a skin disease which covers the whole body, causing the skin to peel off. This infection, called by them "korap", starting from a centre grows outward until the whole body is covered. It is infectious by contact. Contrary to what might be expected of such a people, the morals are distinctly high.

Many of the customs are peculiar. The marriage ceremony is somewhat simple. The prospective bridegroom has already made successive visits to the house

of the bride and has become fully acquainted with the family and has been accepted as the future husband of the daughter. The bridegroom cuts a large supply of firewood sufficient for about three weeks domestic use by the parents of the bride. This he piles up outside the door of the bride's father and so becomes a member of the family and takes up his abode with the bride's parents.

The lives of these jungle natives are controlled to a marked extent by superstition and fear. The various superstitions or fears are connected with a number of individual spirits whose pleasures or displeasures are shown in various ways, but especially by the movement of certain small birds which are constantly to be met in the jungle. When going on excursions to the jungle for hunting or for produce of the jungle the small birds must fly across the path in a set manner, first from one side and then the other before the omen is regarded as good and the journey can be safely undertaken. If the bird gets the signals crossed the omen is a bad one and the journey stops, a camp is made and another trial is made the next day. The Muruts have been seen in the same camp for ten days awaiting the propitious signal for a successful trip.

Deaths are occasions for visits between neighboring villages, the people going en masse from one village to the other. Rice spirit (arack) is consumed on these occasions, and under the influence of liquor brawls may be started and in the heat of the moment a parang (native sword) is easily drawn and some wound inflicted which may be followed by a mortal combat. In such a way do feuds arise between one group and another. Others may arise by reason of high handed methods in bargaining or refusal to pay debts real or imaginary. Feuds once started may be carried on until one group is completely wiped out. The head-hunting of the Muruts is done in the pursuit of such feuds.

The Murut is ready to take a head of any kind, man, woman or child. The Dyak prefers a man's head taken in open daylight personal combat. The Murut will steal upon his foe by night and put the muzzle of his musket as close to the body of the victim as possible, shoot, and

then fly like the wind regardless of thorns or brambles tearing his legs. Or, if the parang is the weapon used, he will approach at dead of night and strike the victim while asleep. The only window in the Murut house is a narrow strip about six inches high at the base of the shallow wall between roof and floor. As soon as approaching darkness makes it necessary to light a torch of resin this window is closed by lowering a plank across it. This prevents the enemy from poking his gun through the opening or blowing poison darts through it.

After taking heads a series of festivities are carried on for a month. Long poles are erected outside the house, one for each head, and these are decorated with long strips of wood shaving. The Muruts do not care to exhibit their festivities to the observation of the white man, but one of them witnessed by the writer was a dance performed by all members of the house marching closely one behind the other, all stepping forward with the same leg together, with hands on the shoulders of the one in front. The leader moves about in a snake-like path, followed by the whole column, which winds back and forth across the wide corridor part of the house, chanting meanwhile a peculiarly doleful tune. This may be kept up indefinitely.

The wealth of the Murut is measured by so many pigs or so many jars. The jars are about four feet high and two feet in maximum diameter, with a mouth about six inches across. These jars are of Chinese manufacture and are gaudily colored and patterned and very well made and glazed. They are used for funeral purposes, so several members of a wealthy Murut's family may be interred in jars. The jar is split about the middle and the body placed in it in a doubled up posture. The break and the mouth of the jar are sealed with clay. A hole is made in the base and a bamboo tube is inserted and sealed with clay. The bamboo leads to the ground and serves as a carrier of liquids to the earth. After being closed up in this way the jar is placed in a small hut erected some distance away from the house and offerings are placed in front of it from time to time.

Purely native art includes the making of clay pots for cooking rice, simple or slightly ornamented; the weaving

of bark fibre coats; the carving of bamboo pipes and bamboo carry-alls which serve the coatless Murut for pockets. Pigments used are few. A vegetable black dye is used, and brown and red ochres are obtained from limonite and hematite. A much brighter waxy red coloring stain is used on the bamboo surfaces. It is obtained from the crushed seed pod of the rotan cane which is a creeper. This creeper attains a thickness of stem of half an inch. The outer part is cut off in narrow strips and is utilized by the white man for cane-bottomed chairs. The native of Borneo finds a multitude of uses for this strong, durable and pliable material. A hut built without nails will be securely lashed together at all joints with this material.

In the interior of Trusan district is a group of Muruts two hundred strong who practice a type of irrigation on the drained floor of a former lake. They have the notion that theirs is the largest and most thickly populated community on the earth.

PAPERS ON BIOLOGY AND AGRICULTURE

INTERESTING RESULTS FROM BIRD-BANDING ACTIVITIES

FRANK SMITH, UNIVERSITY OF ILLINOIS

There is abundant evidence in support of statements frequently made in recent years, intimating that bird banding has led to results of greater general interest to bird lovers than those now being gained from any other single source. Because of the recent increase in the number of workers actively engaged in bird banding, there is promise of results of still greater interest in the near future. Literally thousands of birds are now wearing the little aluminum bands which are being supplied by the Bureau of Biological Survey of Washington, D. C., each bearing its own special number which furnishes the clue to the locality and date of banding, and to the person by whom the band was attached. The subsequent recapture of such birds has already proven positively that it is a common thing for birds of certain kinds that make annual migrations of hundreds or even thousands of miles to return to the same locality during successive summers, and sometimes use the same nesting sites, and even occasionally have the same mates as in previous summers. It has been shown that young birds may return in summer to their birthplaces for their summer homes. Data have been obtained showing the return of birds to the same winter homes and to the same localities while on successive migration journeys. Knowledge has also been gained concerning the age attained by certain individual birds. A Brown Thrasher that had been banded early in 1915 was recaptured in 1922, when it must have been at least about eight years old. Of importance also is the information obtained concerning the general routes followed by individual birds and the places of sojourn during their annual migrations.

Obviously it is essential for the maximum success in gaining these results that there shall be not only as many recaptures of banded birds as possible, but also that the recoveries of bands from dead birds shall be as complete as possible. For such recoveries of bands from dead birds dependence is necessarily based quite largely on the cooperation of the general public. Such cooperation can

be realized to the fullest extent only when this general public understands something of the significance of these bands, what to do with them when found, and of the desirability of examining all dead birds found in order to learn whether they had been banded. It is especially desirable that all teachers shall be informed of the nature and importance of this banding work and that they pass the information on to their pupils. Active cooperation of the newspapers in disseminating such information is especially desirable. It should be made clear that bands taken from dead birds are to be returned to the Biological Survey, Washington, D. C., together with statements giving the date when found, the locality, and the cause of death, if known. If living birds with bands are captured, they should be released without removing the bands, but the number should be carefully noted and statements giving the number, date and locality sent to the Biological Survey. Without information from some outside source the finder of such bands will, in many cases, not know what they are for, nor what to do with them. The bands in common use have on the exposed surface the number and the abbreviation: Biol. Surv. On the reverse side is the abbreviation: Wash. D. C. Unless the band is removed and both sides examined the finder will not learn where the band should be sent since, even if he knew the meaning of Biol. Surv., he might suppose it to refer to some state survey. Such removal of the band from a bird in an advanced stage of decomposition might not be made unless the finder understood the purpose of such bands.

I have been interested in an attempt to summarize the data contained in various published records which involve the return of birds to the same summer or winter homes in subsequent years. I wished to learn what different kinds of birds are found to do this; how many records are already available for such species; and also how widely distributed over North America are the localities in which records have been secured. Among the published record lists examined is a recent one by F. C. Lincoln of the U. S. Biological Survey covering the period from January 1, 1920 to June 30, 1923; another one which has appeared in six recent numbers of the

Canadian Field Naturalist and includes records involving Canadian territory; also the records published by S. P. Baldwin of Cleveland, Ohio, and W. I. Lyon of Waukegan, Illinois; and still other scattered data found in Wilson Bulletin, Auk, Bird-Lore, and elsewhere.

The great majority of the banding records of adult birds thus far obtained are from kinds of birds which have food habits such that they are readily lured into traps provided with suitable food for bait; or those that have nesting habits such that the birds may be easily captured during nesting activities. From many well-known kinds of birds no banding records are available since the birds are not readily captured and hence few or no specimens have been banded.

I have found six records of Bluebirds that have been recaptured in the same localities in summers succeeding the ones in which they were banded. Three of the records are from three different localities in Massachusetts and the other three are from one locality near Cleveland, Ohio.

Records of the return of Robins to the same localities in summers following the ones in which they were banded are more numerous. Three such records have been obtained in Ontario and about 30 in the United States in localities distributed in 15 different states ranging from Massachusetts to Kansas.

Very few thrushes have been banded. A Hermit Thrush banded in Georgia in February, 1917, and retaken in the same locality in 1920 is the most interesting record. This of course implies a return to the same winter home or to the same locality on a migration route, and not the same summer home.

A record of a Ruby-crowned Kinglet banded in March, 1923, in Georgia and recaptured in the same trap in January, 1924, also involves a return to the same winter home and is the only return record of Kinglets noticed by me. Their summer range is chiefly north of the United States.

House Wrens are among the best known of those making regular returns to the same summer homes. We have one such record from Ontario and 26 records from localities in seven states ranging from New Jersey to Illinois.

There is a record of the same two birds being mated in two consecutive seasons.

Brown Thrashers furnish 26 records of returns in subsequent years in nine localities ranging from New Jersey to Kansas and from Illinois to Georgia. Most of these records are from localities north of their ordinary winter range and hence have to do with individuals that migrated. In Georgia two banded mates of 1915 were again mates in 1916.

I find 21 records of the return of Catbirds to former summer homes in seven states ranging from New Jersey to Kansas. The winter distribution of the Catbird is given as Florida and farther south.

Return records of warblers are very scanty and are limited chiefly to Myrtle, Palm, and Pine Warblers returning to their winter homes. Myrtle Warbler records show several individuals returning after three years to the same locality and one specimen four years after first being banded.

Few specimens of swallows are banded and records are scanty. One Bank Swallow banded in Alberta, Canada, in July, 1922, returned to the same station in July, 1923. They winter far south.

Tree Swallow return records are limited to three from Canada, two of these at Ottawa, Ontario, and a third one in Manitoba. This later one banded May 27, 1923, returned to the same bird box on May 10, 1924. They winter far south.

One Barn Swallow record from Saskatchewan is of a bird banded in May, 1923, which was recaptured in June, 1924, and nested in the same building it had used the preceding year. They also winter far south.

The Fringillidae, being seed eating birds, are easily trapped and have been banded in large numbers and records of returns are correspondingly numerous, especially from a few species of sparrows.

A Rose-breasted Grosbeak banded in 1919 at Waukegan, Illinois, was retaken at the same place in 1920 and again in 1923. They winter in Central and South America.

A Towhee record is of a specimen taken two successive summers at a locality in Massachusetts.

Over 70 records are found of Song Sparrows that have returned to the same summer homes ranging from Ottawa, Ontario, to Manitoba and in seven states including New Hampshire and Illinois.

Seventeen records of Chipping Sparrows showing similar returns include Ontario and seven states from Maine to Michigan. Of especial interest is a record in the last number of Auk from Cohasset, Massachusetts, of a banded pair of Chipping Sparrows that reared a brood in 1923 and returned to the same place in 1924 and reared two broods.

There are numerous records distributed over a considerable range of territory which show that specimens of Slate-colored Juncos, White-throated Sparrows, and Tree Sparrows have returned to the same winter homes for one or more seasons.

Records of 35 Purple Finches show returns to the same summer homes in succeeding years. These records are from Massachusetts and Northern Michigan.

One record each from Massachusetts, Illinois, and Saskatchewan show specimens of Bronzed Grackles returning to the same summer homes.

Two records deal with two Cowbirds that returned to the same locality in Northern Illinois for a second summer.

Chimney Swift records are few in number, but very interesting. These birds are reported as wintering in Central America. A Kansas record shows that a specimen banded in 1922 returned to the same locality in 1923. The most surprising record is from Ohio of a bird banded in June, 1916, and retaken in the same chimney in June, 1917, and again in June, 1921. It was recaptured in the same locality in 1922 and 1923, but whether or not from the same chimney is not stated. Banded in 1916, when at least a year old, it must have been eight years old anyway when taken in 1923.

The only record of the return of a Nighthawk to its summer home, of which I know, is one not yet published but soon to appear. These birds are frequently found rearing their young on the gravel roofs of buildings in cities. A well-known ornithologist of New England succeeded in banding a female nighthawk and young, at

home on the roof of a high school building. The following summer the same female returned to the same roof and reared another family.

A Flicker record shows the presence of one specimen in Northern Ohio in the summer two years subsequent to the one in which it had been banded, and in the same locality. Another specimen banded in Northern Illinois was retaken while using the same nest hole that it had used the preceding summer when it was banded. A third record from Manitoba is similar, while a fourth one from Alberta is of a male which was banded in the summer of 1923 and returned in 1924, and was taken at the same nest hole and with the same mate as in the preceding summer.

Two northern records for Mourning Doves taken in the same localities in succeeding summers are from Ohio and Kansas.

A Florida Gallinule which was banded in Ontario was retaken at the same place the next summer.

There are great numbers of records based on bands recovered from dead birds that indicate something of the direction and distances travelled in the course of their migration activities. Nearly all of the records from water birds are of this kind.

BIOLOGICAL CHARACTERS AND BIOLOGICAL PRODUCTS

CASPER L. REDFIELD, CHICAGO

The word "Biology" comes from a Greek word meaning "Life," and the science of Biology is or should be a science of life. But what is life?

Under the head "Life" in the Encyclopedia Britannica, it is said that "the definition of life must really be a description of the essential characters of life". The article from which that quotation is taken is two pages long; yet there is in it not one word about any "character of life". We are told only about the structure in which life sometimes exists, but nothing about life itself. To meet this situation we must use some illustrations.

A cow will produce milk. That is, she can produce milk if she is alive, but not if she is dead. From this it is evident that the power of producing milk is a character of some form of life, and consequently it is a biological character. But the milk is not a character of life. It is a product of life, and consequently a biological product. There is a fundamental distinction between milk and the power of producing milk.

A cow can be regularly bred provided she is alive, but not if she is dead. From this we see that the power of reproduction is a characteristic of life. If a cow is regularly bred and regularly milked, she will produce a certain quantity of milk when she has her first calf, a greater quantity when she has her second calf, still more when she has her third calf, more yet when she has her fourth calf, and so on up to at least her tenth calf.

Here we see that one characteristic of life is the power of producing a product, and another characteristic of life is that the first characteristic is increased by its own activity. Stating the matter in other words, the development of powers by exercise is a biological character.

Power of producing milk is an inherited character, as is evident from the fact that it is found in a cow when she has her first calf, and power of producing milk is an acquired character, as is evident from the fact that it increases from year to year in cows which exert themselves in the production of milk. The inherited char-

acter and the acquired character are identical characters: and the fact that acquired characters are inherited is seen from the fact that the later calves of a cow inherit greater milk-producing power than do her earlier calves.

If you plant an acorn, it will grow. That is, it will grow if it is alive, but it will not grow if it is dead. Thus we see that the power of growth is a characteristic of life, and consequently it is a biological character. We also see that a physical body is not a biological character, and that is true even when that body is the germ plasm of a seed. The seed may be dead.

When an acorn grows it will become a tree, and in due time that tree will produce a thousand other acorns. In each of those thousand acorns there is just as much life as there was in the original acorn from which the tree grew. In other words, that tree gives forth a thousand times as much life as it inherited, and it still has more left on hand than it had in the first place. That extra life did not come from nowhere out of nothing. It was acquired by the tree in its process of living, and what those thousand acorns inherited was what the parent tree acquired. It is a characteristic of life that it can absorb powers from the inorganic world, and can transform those powers into new life which is inherited by offspring.

If you cut off the tail of a mouse, that tail will stay off, and that is true whether the mouse is alive or dead. Thus we see that the tailless condition is not a character of life, and consequently it is not a biological character. It is an effect produced by the non-biological environment.

Weismann cut off the tails of mice, and he then bred those mice. He cut the tails from the second generation of mice, and then bred those mice to get a third generation. He cut the tails from the third generation and then bred those mice to get a fourth generation, and so on for many generations. The last generation had just as good tails as the first. This is an illustration of the fact that non-biological things are not biologically inherited.

If you cut off the tail of a mouse, there will be produced a wound, and the wound will heal. That is, the wound

will heal if the mouse is alive, but it will not heal if the mouse is dead. The healing of a wound depends upon the existence of life, and consequently the power of healing is a biological character. When Weismann cut off the tails of mice, the wounds healed. He then bred those mice and cut the tails from the second generation. Again the wounds healed, and he bred the second generation of mice to get the third, and so on for many generations.

Did those wounds heal more rapidly in the later generations than in the earlier ones? Unfortunately, Weismann did not tell us; yet that wound-healing was the only biological thing associated with that tail-cutting operation. The fact that the non-biological part of this tail-cutting experiment is cited at the present time as evidence against inheritance of biological things is itself evidence that real biological characters have not been given proper consideration. And the fact that biological characters have not been given proper consideration is the reason why the article on "life" previously referred to does not tell us anything about life.

When the germ of a mouse starts on its embryonic career it will produce a tail provided the germ is alive, but not if it is dead. We thus see that the production of a tail is dependent upon the existence of life, and the tail is a product and not a character of life. There is a distinction between a tail, and the power of producing a tail.

Biological characters are characteristics of life itself. Biological products are physical structures which are built by life. Another distinction between biological characters and biological products is that characters are inherited and products are not. A man does not inherit a Roman nose. He inherits a life which builds a nose in one generation in substantially the same form that it built it in previous generations. Or, if we wanted to be technically accurate, we would say that there is no such thing as inheritance. There is only a continuity of expanding and contracting life which repeats over and over the same things it did in previous generations.

Life has the power not only of building structures, but it has the power of tearing down a structure already built and rebuilding the material into a structure of a

different form. A caterpillar will spin for itself a cocoon within which it is shut away from the environment. Here it will tear down the caterpillar structure and rebuild the material into a butterfly. The butterfly structure is very different from the caterpillar structure, but the same life is in both of them. A biological character is not determined by the structure in which it is found.

When the lens of the eye of a newt is torn out, the life in the newt rebuilds that lens from totally different tissue found in the edge of the iris. When Lewis cut the developing eye of a tadpole from connection with the brain and pushed it back under the skin to the region of the shoulder, the life in that tadpole used part of the skin as material out of which to build a lens for that eye.

If an egg is kept warm so that it does not have to radiate heat to the atmosphere, that egg will develop into a chick. That is, the egg will develop into a chick provided it is alive, but will not if it is dead. In this process the life within the egg tears down the structure within the shell, and rebuilds the material into a new structure in which there is a complicated series of organs formed of bones, muscles, skin, feathers, and so on.

In all of these cases biological characters build structures, and these structures are biological products. But no structure can produce life. Life is not a function of structure, as is sometimes stated. If it were, then there could be no such thing as a dead animal because it is impossible to separate a function from the thing of which it is a function. Life is a distinct entity just as heat, light and electricity are distinct entities.

A horse can be trained and raced provided he is alive, but not if he is dead. This means that the power of racing is a biological character. When a horse is trained and raced he will gain in racing power just as a cow will gain in milk-producing power when regularly milked. By the records we learn that if the horse is trained and raced year by year he will continue to gain in this biological character up to at least seventeen years of age. We also learn by the records that under continued training a horse may develop a racing power beyond any

possible inheritance. That is always the case when a horse becomes a champion, at either trotting or running.

When a horse which has been trained and raced is permitted to stand idly in stall or paddock for some years, he gradually loses his racing powers. This biological character gradually dissipates. But as a character cannot be separated from the thing of which it is a character, the thing which really dissipates is life itself. It is a characteristic of life that it adds to itself by its own activity, and correlatively, it is another characteristic of life that it dissipates and becomes less by inactivity.

During the middle part of the last century there was established a doctrine of energy, and certain laws of thermodynamics. There are two laws of thermodynamics, the second of which is stated in such technical language that it is not generally understood. These laws are limited to the relationship of heat to force and motion, but for our purpose we will broaden them out to cover all forms of energy. Energy, by the way, is defined as stored work, and all forms of energy are measured in terms of work.

The first law of energy is known as the Conservation of Energy. This is a simple statement which means that no matter what may be done, or how many times energy may be transformed or shifted about, no new energy can be brought into existence, and none of that in existence can be destroyed. No one has yet made a perpetual motion machine, or found anything else to cast doubt on this statement.

The second law of energy is more complex, but may be set forth in simple language under three heads.

(a). For energy to perform work, it must exist at a high potential, and must run down to a lower potential. Examples: If a spring is the instrument thru which energy operates, the spring must be wound up, and the tighter it is wound the more work can be performed. If water is the instrument, then the water must be raised to an elevated position from which it can run down, and the greater the elevation the more work can be performed. If a gas, such as air or steam, is the instrument, then the gas must be under pressure, and the

greater the pressure the more work can be performed when it expands to a lower pressure.

(b). Energy left to itself always dissipates. This is known as the Dissipation of Energy. Examples: When an object is heated to a high temperature and permitted to stand, the heat will gradually radiate away. If a storage battery is charged and permitted to stand, the charge leaks away.

(c). Energy can be raised from a lower to a higher potential only by the performance of work. This is a logical consequence of (b), and can be illustrated in many ways. It requires work to wind a spring, to elevate water, to compress a gas, and so on.

For convenience we may make a third law out of the statement that all forms of energy may be transformed into each other, either directly or indirectly. We transform heat into motion, motion into electricity, electricity into light, light into chemical action, chemical action into heat, and so on.

When put to the test, it is found that biological characters in general, and even life itself, respond perfectly to all three of these laws, and to all of the sections of the second law. This means that life itself is a form of energy, and that the laws of energy are the most fundamental of biological principles. A few illustrations will serve our purpose.

When you wind up a spring you store work (energy) in that spring, and the energy thus put into the spring is identical with the energy we know in mechanics. It can be used to perform the same kind of work as if it came from a steam engine. This energy stored in the spring is not newly created energy. It came out of your muscles, and was part of the store of energy you had there.

If you work hard at winding springs without rest, you will become fatigued, and fatigue is simply a signal that the energy supply in your muscles is becoming depleted. If you work hard enough and long enough without rest, you will cause your own death from no other cause than the abstraction of energy. If abstracting energy is abstracting life, that fact shows that life is a form of energy.

The racing power of a race horse is the power of moving a physical body from one place to another, and that is the same power we know in mechanics. When a race horse stands idle for a considerable time, his racing power declines as the result of that idleness, and this decline is in accordance with section (b) of the second law.

When a horse is trained, he is worked until his energy supply is partly, but not injuriously, depleted, and he is then permitted to rest until his energy supply is restored. He is again worked and again rested, and so on. Under this system, the energy potential in his muscles is gradually increased, that is, more energy is stored in the same weight or bulk of substance. This is in accordance with section (c) of the second law.

You have mental energy stored in your brain cells, and that mental energy enables you to think. You also have muscular energy stored in your legs, and that muscular energy serves you for locomotion. It is clear that mental energy and muscular energy are not the same. But if you run a foot race until you are tired all over, you are in no condition to think clearly. The mental energy stored in your brain cells has been transformed into muscular eneregy and has been expended thru your legs. This is in accordance with what we have called the third law, and shows that while mental energy and muscular energy are of different species, they are of the same genus.

A man is useful in this world for what he does, and not for what he looks like, how tall he is or how much he weighs. This means that the essence of value in a man or any other living thing is in the biological characters, and not in the biological products. It is common to think of biological structures as being the real things, and energy or life as being a tool which structures use, but that is an erroneous view to take.

Physiologists and biologists in general claim that their conceptions are fundamentally mechanistic, but to be mechanistic they must accord with the principles of mechanics. In mechanics, the motive power is the essential thing, and is recognized as being the same no

matter what form it may take. Given the power, the same work may be accomplished with any one of a great variety of tools, all of which are structures.

The same is true in the biological field. Given the necessary life, the same work may be performed by animals of widely different structures, or even by plants. If a tree is alive, it will raise tons of water for hundreds of feet by structures very different from those found in a pumping station, or in animals which also raise water to elevated positions. It will not do to ascribe these forces to the environment. There is nothing in the environment which will cause sap to flow upward in a tree if the tree is dead.

RESISTANCE OF EARTHWORMS TO SOIL ACIDITY

MARY M. STEAGALL, STATE NORMAL UNIVERSITY, CARBONDALE

The following bit of experimental research was undertaken at the suggestion, and under the direction of Dr. W. C. Allee, Department of Zoology, the University of Chicago, during the year of 1923, following an article by O. Arrhenius, "Influence of Soil Reaction on Earthworms", published in Ecology, Vol. II, No. 3, pp. 193-197, 1921.

The results as here given are from a second set of experiments performed with earthworms involving the chemicals, H_2SO_4, KOH, HCl, NaOH, & $C_{14}H_{10}O_9$. The purpose was to determine the influence of varying soil acidities on earthworms and to study the difference in resistance between some of the common varieties of the same.

Four different species were used. As determined by Miss Hyman they were:

Octolasium lacteum.

Allolobophora foetida.

Megascolecidae.

Lumbricus terrestris.

The above species were put in as nearly similar conditions as possible. Five individuals were used in each pot of earth.

In the use of chemicals, KOH was used in the series with tannic acid, and NaOH was run in that with HCl. In a previous experiment H_2SO_4 had been run parallel with HCl for comparison of results. All acidities were run with each species of earthworm and the results tabulated for comparison.

In the first experiments titrated normal acidities, with exact percents of acidity, were used for securing the soil acidities. This was found impracticable, since the buffer in the soil gave reversal of action such that exactness of normality counted for nothing. In this experiment measured normalities were used and percents of these solutions to water the soil to bring it to the desired acidity.

The percents used were n, n/2, n/5, n/10, n/20, n/100 respectively. The soil used had an initial pH of 8, so that any percent less than n/100 had no practical value for the experiment.

The amounts of the solutions used to bring about the desired acidities depended on the buffer in the soil, on the time elapsing between treatments, the length of time since the last treatment, the temperature of the soil and perhaps some other external conditions of atmospheric conditions, etc., on the initial pH value; so that these will be passed over and the data will begin with the final experimental values. Data on the two series only will be given in this paper.

In each series twelve pots were used. Of these, ten represent those treated to secure the range of acidities; Nos. 5 and 6 are the controls, watered with tap and distilled water respectively.

In the first experiments inorganic acids only had been used. In this set one organic acid was chosen, the one probably most common in our soils, tannic acid. The action of the HCl and that of the tannic acids were very different in their effect on the soil itself. The HCl produced a strong reaction in contact with the Calcium of the soil, so much so that the soil for days boiled over the top of the pots and thus became full of small air spaces. In the treatment with the tannic acid there was no effervescense, but a black sediment settled on the inside of the pot which later passed through the porous earthenware and blackened even the outside. The soil in this case became very loamy, crumbling like sand.

When the desired acidities were secured, the pots were placed in an underground room with temperature 25-27° C. In order to prevent the escape of the worms they were covered with plates of tin and set in stone trays sprinkled with fine soil, that any escape might be detected. The worms were used always within about two days after digging, so as to provide the best chances for life, and to give opportunity for any injured in the process to be cast out.

In the given tables the following abbreviations are used:

TA—tannic acid
g—good condition
d—dead
sl—sluggish
ot—ontop of the soil
ex—outside the pot
np—between earth and pot
k—tied in knots
A—worms added
R—worms replaced
7-9—alkalinity
5-7—acidity
y—young worms
ls—large size

Octl—Octolasium lacteum
Allo—Allolobophora foetida
Mega—Megascolecidae
Lumb—Lumbricus terrestris
p—poor condition (below medium)
b—bad condition, nearly dead
m—fair to medium condition
dp—worms dead where placed
sg—soil in good condition
sc—Soil crumbling, loamy
sp—Soil puddled, sticky
co—cocoon
sw—soil wet
to—taken out

In the results each species is first given separately, with its peculiar reactions and resistance to each series; then the results of each given for comparison of species; next the effect of each chemical on our common species, and finally the effect of the tannic acid series during the longer period of twenty-one days.

The soils were tested with the LoMotte Indicators, purchased new at the beginning of the set of experiments.

Octolasium lacteum was abundant in all moist soils, testing from 7.8 to 8.0 pH. Characteristic of garden and forest loam.

Allolobophora foetida was abundant with Megascolecidae in the refuse and leaves through out from the greenhouse, soils testing 8.0 pH.

Lumbricus terrestris was not so easily found, but was most abundant near a building, or in the loose turf on the lawn, in soil testing 7.5 to 8.0 pH.

Octolasium lacteum, which was used in the first experiments also, is taken as the basis for comparison of the action of the different chemicals used in producing acidities, as the best type. It was always in medium conditions, not too wet, too rich, nor too sandy.

TABLE I.

Reaction of Octolasium Lacteum to KOH and TA Series.

Pot	pH	Worms	1-da.	2-da.	pH	3-da.	4-da.	pH	7-da.	8-da.
1	9.0	5	3b, 2d	od-R	8.0	3b, 2d	od—	8.5		
2	8.5	5	4m, 1k	5sl	8.4	5k	4k, 1ls	8.5	2k, 3d	1b
3	8.2	5	5g	1m, 4np	8.0	4m 1d	5g	8.2	4p —	2m 2k
4	8.0	5	5g	1m 4ot	8.0	5g, sp	5g	8.0	5m	3g 2k
5	8.0	5	5g	5g	7.5	5g np	5g	8.0	5m	3g 2k
6	8.0	5	5g	5g	7.5	5g sp	5g	7.5	5g	4g —
7	7.8	5	5g	5g sg	7.0	5g	5g	7.5	5g	4g —
8	7.5	5	5g 3np	5g np	6.5	5g sg	5g ls	7.4	5g ls	5g ls
9	7.2	5	5g 3np	5g np	6.2	5g ls	5g ls	7.2	3g ls	5g ls
10	7.0	5	5g 3np	5g np	6.0	5g ls	5g ls	7.2	5g ls	5g ls
11	6.2	5	5g	5g	6.0	5g ls	5g ls	6.5	5g ls	5g ls
12	6.0	5	5g	5g sg	5.5	5g ls	5g ls	6.0	5g ls	5g ls

TABLE I—Continued.

Pot	9-da.	11-da.	12-da.	15-da.	pH	16-da.	17-da.	21-da.	25-da.
1	R	0d	—	—	8.5	—	—	—	—
2	0d	R	—	—	8.2	—	—	—	—
3	3b 2d	2m 1d	1m	1b	8.0	—	—	—	—
4	4m	4m	4m	3k 2p	7.8	3b	1b 2d	—	—
5	5g	5g	5g	5g	7.5	5g	5g	5g	5g
6	4g	4g	4g	4g	7.0	4g	4g	4g	4g
7	4g	4sg	4g	4g	7.0	4m	3m	3m	od
8	5g	5g	4g 1d	4g	6.8	4g	3m	3m	3m
9	5g	5g co	5g	5g	6.6	4g	4m	4m	3m
10	5g	5g ls	5g ls	5g	6.5	4g 1d	4g	4m	4m
11	5g	5g sl	5g sl	5g sl	6.4	4g 1d	4g	4m	4m
12	5g	5g ls	5g sw	5m	6.0	2 sl 3d	2m	2p	2d

TABLE II.

Reaction of Octolasium Lacteum to NaOH and HCl Series.

Pot	pH	E-W	1-da.	3-da.	7-da.	12-da.	pH
1	8.8	5	4m	4m	1b	0d	8.5
2	8.6	5	3m	3m	3k	3p	8.5
3	8.2	5	1p 4d	0d	—	—	8.0
4	7.8	5	5g	5g 1d	0d	—	7.5
5	7.6	5	5g	5g	5g	5g	7.5
6	7.2	5	4g 1d	4g	3g 1d	3g	7.2
7	7.2	5	3p 2d	3p	1p 2d	0d	7.2
8	7.2	5	5 0d	—	—	—	6.5
9	7.0	5	0d sp	—	—	—	6.4
10	6.6	5	0d sg	—	—	—	6.2
11	6.5	5	0d sg	—	—	—	6.2
12	6.0	5	0d sp	—	—	—	6.0

TABLE III.

Reaction of Allalobophora Foetida to KOH & TA Series.

Pot	pH	E-W	1-da.	2-da.	3-da.	6-da.	pH	7-da.	8-da.
1	8.5	5	5b	od...	...	—	8.5	—	—
2	8.5	5	3b 2d	3m	3g	3g	8.2	3g 2y	3g 2y
3	8.2	5	5g	5g	5g	5m	8.0	4m 1d	4m
4	8.0	5	5m	5g	5g	5m	7.8	5m	4m
5	8.0	5	5g	5g	5g	5g	7.5	4m 1d	4m
6	7.5	5	5g	5g	5g	5g	7.0	4m 1d	4m sp
7	7.5	5	5g	5g	5g	5g	7.0	5g	5m
8	7.4	5	5g	5g	5g	5g	6.8	5g 3y	5g 3y
9	7.2	5	5g	5g	5g	5g	6.6	5g	5g
10	7.2	5	5g	5g	5g	5g	6.5	5g	5g
11	6.5	5	5g	5g	5g	5g sw	6.4	4g 1d	4g
12	6.0	5	5g	5m sw	5m	5m	6.0	5m	5m

TABLE III.—Continued.

Pot	10-da.	11-da.	13-da.	16-da.	21-da.	pH
1	—	—	—	—	—	8.5
2	3g 3y	3m 3y	3g 3y	3g 3y	3g 3y	7.5
3	4m	3m sp	3m sp	3m sp	3m dp	8.0
4	4m	4m 1y	4m —	4m	4m	7.5
5	4m	4m	4m	4m	4m	7.5
6	4m	4m	4m	4m	4m	7.0
7	5m	5g	5g	4g 1d	4g	7.0
8	5g 3y	5g 2y	5g 2y	5g 5y	4g —	6.5
9	5g 1y	5m	5g	4g 1d	4g	6.4
10	5g	5m	5g	4g 1y	4g 1y	6.2
11	4g	4m sw	4m sw	4m 1y	4m 1y	6.2
12	5m	5m sw	5m sw	5m sw	4m 1y	6.0

TABLE IV.

Reaction of Allobophora Foetida to NaOH & HCl Series.

Pot	pH	E-W	1-da.	pH	2-da.	pH	5-da.	pH	6-da.	7-da.
1	8.5	5	5g np	8.5	4m 1p	8.5	5g	8.5	5m	5g
2	8.5	5	5m 3np	8.4	5m	8.0	5g	8.5	5g	5g
3	8.5	5	5np	8.2	5g	8.0	5g	8.5	5g	5g
4	7.5	5	5g 3np	8.0	5g	7.8	5g	8.0	5g	5g
5	7.5	5	5g 3np	8.0	5g	7.5	5g	7.5	5g	5g
6	7.5	5	5g np	7.5	5g	7.5	5g	7.5	5g	5g
7	7.2	5	5g	6.5	4g 1p	7.0	5m	7.5	5g	5m
8	7.0	5	3m 2p	6.5	od sp	6.8	—	7.2	—	—
9	6.5	5	1b 4d	6.4	odp sw	6.5	—	7.0	—	—
10	6.5	5	od sw	6.2	odp sw	6.0	—	6.8	—	—
11	6.5	5	odp sw	6.0	odp sg	5.5	—	6.5	—	—
12	6.5	5	odp sg	5.5	odp sw	5.5	—	6.0	—	—

TABLE IV—Continued.

Pot	8-da	9-da.	11-da.	pH	12-day.	14-da.	16-da.	19-da.	23-da.	pH
1	5g	5g	5g	8.8	5g	1p 4d	1p	1p	1p	8.5
2	5g	5g	5g	8.6	5g	4m 1d	4m	4g sg	4g	8.2
3	5g	5g	5g	8.2	4g 1d	3m 1d	3m	3m	2m 1d	7.5
4	5g	5g	5g	7.8	5g	5g sp	5g 1y	4g 1d	2m 2d	7.2
5	5g	5g	5g	7.6	5g	5g sp	5g 1y	5g	5g 1y	7.2
6	5g	5g	5g	7.2	5g	5g sp	5g	4g 1d	3g 1d	7.2
7	5g	5g	5g	7.5	5g 1y	5g 1y	3g 2d	3m	3g	7.0
8	—R	0dp	—	7.2	—R	3g 2b	3g 2d	2p 1d	2g co	7.0
9	—R	0dp	—	7.0	—R	0dp sp	—	—	—	6.5
10	—R	0dp	—	6.8	—R	0dp sg	—	—	—	6.0
11	—R	0dp	—	6.5	—R	0dp sg	—	—	—	6.0
12	—R	0dp	—	6.0	—R	0dp sp	—	—	—	—

TABLE V.

Reaction of Lumbricus Terrestris to KOH and TA Series.

Pot	pH	E-W	1-da.	2-da.	3-da.	5-da.	9-da.	12-da.	14-da.	pH
1	8.5	5	0dp	—	—sp	—	—	—	—	8.5
2	8.2	5	3ot 2d	0d—	—sp	—	—	—	—	8.2
3	8.0	5	4g 1d	4m	4k	4k	3k	3k	3k	8.0
4	7.8	5	4g 1d	4m	4p	4k	4k	3k	3k	8.0
5	7.5	5	5m	5m	5m	5m	5m	5m	4m	7.5
6	7.2	5	5g	5g	5g	5g	4g 1k	4g 1d	4g	7.0
7	7.0	5	5g	5g	5g	5g	3g 2b	3g 2d	3g 1y	7.5
8	6.8	5	5g	5g	5g	4g 1k	3k	3k	3k	8.0
9	6.6	5	5g	5g	4m 1d	4k	4k	3k	3k	6.5
10	6.5	5	5g	5g	4m 1d	3m 1k	4m	4m	4m	6.4
11	6.4	5	5g	4g 1b	4m 1d	4g	4m	4g	4g	6.2
12	6.0	5	5g	5g	4g 1d	4g	4k	4g	4g	6.0

TABLE VI.

Reaction of Lumbricus Terrestris to NaOH and HCl Series.

Pot	pH	E-W	1-da.	2-da.	3-da.	5-da.	9-da.	12-da.	14-da.	pH
1	8.8	5	3ot 2m	2ot 3m	3ot 2d	3m	3k	3k	1p	8.5
2	8.5	5	5g	5m	4m 1d	4m	3m 1d	3k	2k	8.2
3	8.2	5	5g	3m 2d	1m 2d	1p	1p	1k	1d	8.0
4	8.0	5	5g	4m 1d	4m	4m	4m	4m	4m	7.5
5	7.8	5	5g	5g	5m	5g	5g	4g 1d	4m	7.2
6	7.6	5	5g	5g	4g	4g	4g	4m	4m	7.2
7	7.5	5	3p 2d	2m 3d	2b	2b	2b	1k 1d	1k	7.0
8	7.2	5	0d—	—	—	—	—	—	—	7.0
9	7.0	5	0dp—	—	—	—	—	—	—	—
10	6.8	5	0dp—	—	—	—	—	—	—	—
11	6.2	5	0dp—	—	—	—	—	—	—	—
12	6.0	5	0dp—	—	—	—	—	—	—	—

TABLE VII.

Reaction of Megascolecidae to KOH & TA Series.

Pot	E-W	pH	1-da.	3-da.	4-da.	5-da.	6-da.	8-da.	12-da.	pH
1	5	8.5	0dp—	—	—	—R	1p 4d sp	0d—	—	8.5
2	5	8.2	1m 4d	0d	—	—R	1m 4d sp	0d—	—	8.2
3	5	8.0	4g 1d	4g	4m	4m	3m 1d	3m	2p	8.0
4	5	7.8	5g	5g	5g 2y	5g 2y	5g 2y	5g 1y	4m	8.0
5	5	7.5	5g	5g	5g	3g 2y 2d	3g 2y	3g 2y	2m 2y	7.5
6	5	7.2	5g	5g	5g	5g 3y	5g 2y	5g 1y	5g 1y	7.0
7	5	7.0	5g	5g	5g	3g 2d	3g 1y	3g 2y	3g 1y	6.5
8	5	6.6	5g	5g	4g 1d	3g 1d	3g 2y	3g 2y	3g 3y	6.4
9	5	6.6	5g	5g	5g 1y	5g	5g	5g	4g 1d	6.2
10	5	6.5	5g	5g	5g	5g 1y	5g 1y	3g 2d	3g 2y	6.2
11	5	6.2	5g	5g	5g	5g 1y	5g 2y	5g 2y	5g 1y	6.0
12	5	6.0	5g	5g	4g 1d 2y	4g 2y	4g 3y	4g 1y	4g 1y	6.0

TABLE VIII.

Reaction of Megascolecidae to NaOH & HCl Series.

Pot	pH	E-W	1-da.	2-da.	3-da.	5-day.	pH	6-da.	7-da.	8-da.
1	8.5	5	5m	5g	5g	3m 2d	8.8	2m 1b	1b 2d	1b
2	8.5	5	5g	4m 1d	4m	4m	8.6	4m	3g 4d	2g 1d
3	7.5	5	5g	4m 1d	4m	4m	8.2	4m 1y	4m	4m
4	8.0	5	5g	3m 2b	5m	5g	7.8	5g	5g	5g 1y
5	7.5	5	5g	5g	4g 1d	4g	7.6	4g	4g	4g 1y
6	7.5	5	5g	5g	5g	5g	7.2	5g	5g	5g
7	7.5	5	5m	5g	5g	5g	7.5	5g	4g 1p	3g 2d
8	7.2	5	0dp	—	—	—R	7.2	0dp	—	—
9	7.0	5	0dp	—	—	—R	7.0	0dp	—	—
10	6.8	5	0dp	—	—	—R	6.8	0dp	—	—
11	6.5	5	0dp	—	—	—R	6.5	0dp	—	—
12	6.0	5	0dp	—	—	—R	6.0	0dp	—	—

TABLE VIII.—Continued.

Pot	9-da.	10-da.	12-da.	16-da.	21-da.	pH
1	1b	1b	0d—	—	—	8.5
2	3m	3m 2y	3g 2y	3k 1y	0d sp	8.2
3	3g 1d	3m 2y	2g 1d	2g	1b	8.0
4	5g 1y	5g 2y	3m 2d	3k	2k	7.5
5	4g 1y	4g 1y	4g 1y	4m	2p	7.2
6	5g	5g	5g	4m 1d	2m 2d	7.2
7	3g	3g	3g	3g	3g	7.0
8	—R	0dp	—	—	—	6.8
9	—R	0dp	—	—	—	6.5
10	—R	0dp	—	—	—	6.2
11	—R	0dp	—	—	—	6.2
12	—R	0dp	—	—	—	6.0

0dp—died in place.

TABLE IX.

Effects During Twelve Days of the Two Series of Chemicals on the Different Species of Earthworms.

	Series: KOH & $C_{14}H_{10}O_5$						NaOH & HCl Series.				
pH	Octl.	Megl.	Allo.	Lumb.		pH	Octl.	Megl.	Allo.	Lumb.	
8.8	—	—	—	—	KOH	8.8	0	0	100	20	NaOH
8.5	0	0	0	0		8.6	60	60	100	40	
8.2	0	0	60	0		8.2	0	40	80	0	
8.0	20	40	60	60		8.0	—	—	—	80	
7.8	80	80	80			7.8	0	60	100	—	
	—	—	—	—			—	—	—	—	
7.5	80			60		7.5		60	100	20	HCl
7.2	90	—	—	—	TA	7.2	0	0	0	0	
7.0	—	60	100	—		7.0	0	0	0	0	
6.8	—	60	100	—		6.8	0	0	0	0	
6.5	100	—	100	75		6.5	0	0	0	—	
6.2	—	80	—	80		6.2	—	—	—	0	
6.0	100	90	100	80		6.0	0	0	0	0	
7.5	100	40	80	80	Tap w	7.0	100	80	100	80	
7.0	80	100	80	60	Dist.W	7.5	60	100	100	80	

TABLE X.

Comparing Effects of Different Chemicals used on the same Species.

	Octolasium		Allolobaphora		Megascolecidae		Lumbricus		
pH	KOH	NaOH	KOH	NaOH	KOH	NaOH	KOH	NaOH	
8.8	0	—	—	100	—	—	—	—	
8.5	0	10	0	100	0	0	0	20	
8.2	0	—	—	80	0	60	0	60	
8.0	20	0	60	—	40	40	60	60	
7.8	90	0	60	100	80	—	—	—	
7.5	—	0	80	100	—	60	100	70	
7.2	TA	HCl	TA	HCl	TA	HCl	TA	HCl	80
7.0	80	0	100	100	—	60	60		20
6.8	80	0	100	0	60	0	60		0
6.5	100	0	90	0	60	0	60		0
6.2	100	0	100	0	80	0	80		0
6.0	100	0	100	0	90	0	80		0
7.5	100	100	80	100	40	80	80	80	
7.0	80	100	80	100	100	100	60	80	Cont'ls

In Table IX it is seen that Allolobophora foetida shows greater resistance to KOH than any other species; also shows the most perfect stimulation in reaction to Tannic acid. The latter is much better than the control.

According to Table VII Megascolecidae far exceeds the other species in its power of reproduction under the stimulation of the tannic acid, yet in Table IX we see that it is below both Octolasium and Allolobophora in its resistance to higher concentrations of this acid.

Of the species used, Octolasium shows the least resistance to three of the chemicals, NaOH, KOH and HCl; yet it is as strong as Allolobophora in its resistance to tannic acid.

Besides its endurance of tannic acid, Allolobophora is the most resistant to HCl and NaOH. If, then, we rank the four species in accordance with their relation to pH concentration, Allolobophora is most resistant, Lumbricoides ranks second, Megascolecidai third, and Octolasium least resistant.

In Table XI are two charts, the first a ranking of the species according to resistance, No. 1 being the least resistant; and the second chart is a ranking of the chemicals according to their deadliness, No. 1 being the most deadly. The first chart is made from Table IX, the second from Table X.

TABLE XI.

Chart 1.

Ranking in Resistance.

Species	KOH.	NaOH.	TA.	HCl.	Rank.
Octl	1	1	4	1	I.
Megl.	2	2	2	3	II.
Allo	3	4	3	4	IV.
Lumb	4	3	1	2	III.

Chart 2.

Chem.	Standing					Rank
KOH	6	7	8	9	30	II.
NaOH	2	18	10	14	34	III.
TA	11	12	13	15	51	IV.
HCl	1	3	4	5	13	I.

From Table X and Chart 2 it is evident that the inorganic acid is the most deadly of the chemicals, and the organic acid the least harmful. Of the two bases used the KOH is the more harmful. From the previous experiment with Octolasium using also the acid H_2SO_4, it was seen that placed with these chemicals it ranks fourth in harmfulness, while tannic acid stands fifth. From this it might appear that not every inorganic acid is deadly; so we must not infer that all organic acids may be stimulating.

TABLE XII.

Data for 21 Days of Two Species in KOH and $C_{11}H_{10}O_5$.

PH	Octolasium KOH		Allolobophora KOH	
8.8	0		0	
8.5	0		0	
8.2	0		50	
8.0	0		0	
7.8	0			
7.5			70	
7.2	TA		TA	
7.0	60			
6.8	60			
6.5	80		80	
6.2			80	
6.0	40		80	
7.0	100	tap w.	80	
7.5	80	distill	80	controls

From Table XII it is seen that when species are carried through the series for a longer time the reactions may be different. What appeared to be stimulation by tannic acid at the end of twelve days now becomes harmful and the animals lose their resistance to strong concentrations. Octolasium has lost all resistance to the power of KOH. That of Allolobophora is nearly gone. Their power to resist the tannic acid is weakening, particularly that of the Octolasium. This shows that the length of the time exposed to a certain acidity is an important factor in the study of resistance of an animal.

From Tables III, VI, VII and VIII it may be seen that certain chemicals seem to effect the reproductive organs in a hastening as well as in a deterioration of the reproductive product. The tannic acid seemed most active in hastening the process, noticeable in the Megascolecidae. In the former experiments with Sulphuric acid the cocoons were very abundant, but the most of them did not develop. The male reproductive organs were greatly distended in the acids, but time has not yet permitted a histological examination.

The ionization of acids decreases with the concentration: so it is evident that the color indicator does not indicate the concentration of the solution—only the ionization. There is much evidence to show that pH concentration of KOH, for instance, was a very different

thing at the close from what it was at the beginning of the experiment. From twelve to twenty-one days of moistening the soil with concentrations of it, though it did not change the ionization, did change the texture of the soil making it a different habitat for worms. This may have been caused by increased concentration, without increase of ionization, or probably by increase of salts by reaction with soil constituents. For instance, the tannic acid soil and that treated with NaOH remained granular no matter how wet, while that treated with KOH and HC_l were soon puddled, and drying did not mend this condition. As a consequence the aeration of the granular and that of the puddled soils was very different, and that, other things being equal, made them a very different habitat for worms. The tendency of the worms to stay next the pot in many cases may have been tied up with this. True it is that they were not so found in the case of the granular tannic acid soil.

Another question that enters into the question of the deadliness of the HCl is that in combination with calcareous soil it forms a soluble salt with the calcium, $CaCl_2$. The salt formed by the sulphuric acid is insoluble, $CaSO_4$. That formed with tannic acid is probably also insoluble. The increase in injury may be due to the soluble salt.

INFERENCES AND CONCLUSIONS

Similar concentrations of acids may ionize differently, and the same pH value may have different concentrations. So the same acid concentration may affect life differently because of difference in pH value or because of the difference in soluble salts formed in the soil.

So the same pH value may affect life differently because of difference in chemical concentration or difference in soluble salts.

Different chemicals placed in similar soils may produce better or poorer aeration of soil, thus creating different soil habitats, even with the same pH value.

Animals accustomed by natural environment to different habitats may differ greatly in their reaction to a given habitat. Thus Allolobophora found in manure is

most resistant to all pH values, while Octolasium of ordinary lawn soil, of all our common species of worms, may be least resistant of the pH values.

Because a soil puddles is no sign that it is acid, and not all acid soils puddle.

A habitat that appears stimulating for a short period of time may prove in the long run very injurious.

REFERENCES.

"Influence of Soil Reaction on Earthworms", O. Arrhenius. Ecology, Vol. II, pp. 255-257, 1921.
"Soil Acidity in Relation to Insects and Plants", Henry Bird. Ecology, Vol. II, No. 3, pp. 193-197, 1921.
"Reaction of Dragonfly Nymphs to Acid Gradient", Fenner Stickney. Ecology, Vol. II, No. 4, pp. 355-357, 1921.
"The Fauna of an Acid Stream", Ninna E. Jewell. Ecology, III, No. 4, pp. 251-254, 1922.
"Effect of pH on Regeneration in the Tadpole", Ninna E. Jewell.

LECTURE-DEMONSTRATION-RECITATION-TECHNIQUE IN BIOLOGY TEACHING

JEROME ISENBARGER, CRANE JUNIOR COLLEGE, CHICAGO

Results of carefully prepared tests have demonstrated that, in so far as fact-getting is concerned, lecture-demonstration methods of biology instruction are superior to laboratory methods. Taking this fact on its face value incurs dangers that need to be pointed out, especially to the young teacher. These dangers emphasize the necessity for a recognition of the definite aims of teaching in biology and of the steps that must be taken by the student in realizing these ends of education. Then should follow the employment of a technique devised to accomplish a specific purpose.

The devotion to the laboratory has, at times, assumed the proportions of a fetich. Faulty pedagogy in connection with insistence upon a certain kind and definite amount of laboratory work has retarded the acceptance of biology in the high school and probably, to some extent, in the college as well. Several misapprehensions of the functions of the laboratory may be pointed out. 1. That the chief facts of a science should be rediscovered in the laboratory. 2. Feeling that the scientific method consists in the observation and recording of facts. 3 Slavish dependence upon outlines and manuals as true laboratory procedure.

The importance of the laboratory in training in science must not be under-estimated. A rational perspective should be set up in order that we may properly evaluate laboratory practice in any given situation. Much time is wasted in the use of the compound microscope in high school classes. The proper use of the projection microscope recommends that instrument highly for the biology work in any grade of school. The laboratory, however, has functions which are clearly and exclusively within its own field as a medium of instruction and training. True functions of the laboratory may be stated as follows: 1. To make clear facts that are not easily visualized without concrete individual demonstration. 2. To give skill and accuracy. 3. To give an appreciation of the scientific

method. 4. To get pupils to think. The laboratory method is the method of research. It is the slowest possible way of getting facts. For this reason, where information is the main objective, the lecture-demonstration-recitation method, being more economical, and at the same time more effective, should be the chief means used.

The excessive use of the lecture method has been the target for criticism for centuries. Socrates warned against its dangers. A number of valid objections can be filed against this method, even as it is used freely in the colleges today. Aside from the pernicious effect which results from a slavish devotion to this method, directly, the high schools suffer, as an indirect result, from the effects of similar methods used in these schools by teachers, just out of college, who, consciously or unconsciously, imitate their college teachers. Quoting from Dr. T. W. Galloway, "In my opinion, the most effective teaching of biology today is being done in the best high schools by teachers who have been forced to acquire a pedagogical background that would enable them to reconstruct completely their presentation of the subject. Most of these people received very little help in this task from their college courses in biology. For this reason every college teacher will profit by what has been written by the secondary school teachers." The notion, which is quite prevalent, that scholarship is the only prerequisite to successful teaching has done much harm. Says Paul Clapper under the heading, "Professional training for college teachers", " 'We consider the Ph. D. a scholar's degree and not a teacher's degree,' says the dean of one of our leading graduate schools. He (the teacher) needs to know the learning process. He needs to know the different methods and aims in the teaching of his subject and, so far as possible, the results attained by each. Too much of the college teaching is blind, groping, chartless and without compass. Instead of expecting each inexperienced teacher to start afresh, he should be set out armed with the epitomized and digested teaching experience of those who have gone before him."

The term, "lecture-demonstration-recitation" has been chosen purposely to call attention to a method of procedure which presupposes in the teacher a knowledge of

subject-matter and specific aims, a recognition of mental equipment and thought processes of the pupil and the employment of a technique particularly suited to the solution of the problem at hand. The teacher's method should be sufficiently flexible and ingenious to avoid the defects which call forth the valid criticisms of the lecture method. It should encourage pupil activity. Subject matter should be presented in such a way as to leave permanent impressions. The instructor should, at any time, be able to test the accuracy of the student's conceptions and to judge the efficiency of his own methods. This calls for contact between pupil and teacher.

Efficient technique demands a plan, organized about a main purpose, for every class exercise. This requires selection in advance of subject-matter to be presented, illustrative material to be used and, in general, the questions that are to be asked to determine the student's reaction.

As a source of illustrative material, I have found the projection lantern, with specially selected slides, made-to-order slides and home-made slides, almost limitless in possibilities offered. Ordinarily, it is cheaper to buy slides of a reliable slide-maker than to make them. Diagrams and charts made by students may be photographed and the lantern slide positive plate made from the camera negative. In the same way, diagrams and pictures from books may be copied on lantern slides and made a part of the permanent equipment of the department. Photograph negatives of illustrative views from the field may be used directly in making lantern slide positives. A camera using 4″x5″ plates or films should be a part of the equipment of every biological department. If copying is to be done, an additional long-bellows camera will be needed for dark-room use.

Modern projection equipment makes it possible for the instructor to operate his own lantern while in a convenient location for speaking. There are two methods of projection of this sort which recommend themselves from the fact that the room need not be darkened. If the medium-sized lecture room is approximately square, an ordinary projection curtain may be placed across the

darker front corner of the room and the lantern near the middle of the opposite side. A small metal pointer may be used on the front side of the slide. I use a 1,000 watt mazda lamp with resistance, with a combined opaque and slide projector. It is not necessary to draw the shades unless the opaque projector is used.

The translucent screen provides a second and superior means of daylight projection. Any lantern can be equipped with a projection lens of 4⅛" focus together with a suitable condensing system at small cost for this class of projection. An excellent translucent screen may be made of tracing cloth coated with paraffine on both sides. The paraffine is melted and xylol is added to prevent immediate hardening upon cooling. A thin coat is applied with a brush. As the xylol evaporates, the surplus of the wax should be wiped off with a soft cloth. If necessary, use some xylol on the cloth used for wiping. The screen may be bound by sewing on one inch cotton braid. It may be fastened to a frame by means of ¾" snap fasteners. It should be remembered that water will ruin tracing cloth.

The natural psychological process requires that a new topic be presented first as a vague whole. Then should come an analysis, a separation into its parts and a definition of details. Then finally there should be a synthesis consisting of a bringing together of component parts and related details in such a manner as to make clear the relationships of parts to the whole.

With a lantern which can be turned on or off without any attendant fuss of manipulating window shades or directing an assistant, suitable diagrams, photographs or drawings may be thrown on the screen for general impressions; then these can be brought back later for details and summary.

Microscopic detail can be best shown, in so far as class demonstration is concerned, by means of slides made from microphotographs. The proper use for the high power projection microscope is in a dark room where small groups may be taken for special demonstration.

Technique of asking questions calls for skill in setting up situations for questions as well as in questioning. The

development method is here called into use. There is contact with the student. The teacher sees the results of his teaching and the student is trained in habits of systematic thinking and concentration.

The traditional examination for testing the results of instruction, being a test for what is temporary and accidental, is not a safe criterion, in itself, by which to judge the progress of a student. Rating should be on the basis of socially useful knowledge acquired and power gained. The latter is indicated by the facility with which a student is able to interpret situations and solve problems. I have been using a system in my classes which has proven helpful to me as well as to the student. As the course progresses, mimeographed sheets of questions, prepared according to the development method, are given out and used as a basis for quiz periods. They are also used as a basis for all of the written tests of the term. At any time in the term the student has not only a complete record of work covered but also a record of the method by which the different topics were developed. The practice may be open to criticism, but as a device, it has many good points in its favor.

It seems obvious that no one method should be used to the exclusion of other methods of instruction. Effective technique employs different methods. It recognizes the aims of the course and the mental maturity and thought processes of the student, and uses such methods as are best suited to bring about the desired results.

NOTES ON NUT BEARING TREES OF ILLINOIS

A. S. Colby, University of Illinois

An increasing interest is being shown in the growing of nuts in Illinois. Part of this interest has been aroused by reports of the commercially profitable nut industry in the South where the so-called "paper shell" pecan is grown, or in the extreme West, where extensive orchards of the Persian (English) walnut are found. Many are asking whether these nuts can be grown in Illinois either about the home or on a commercial scale as other fruits are grown. Many native nut trees bearing edible nuts are to be found scattered over the state, but comparatively little attention has been paid to them, the general sentiment being that better varieties were available from outside. While this is in some cases true there is danger in importing species not adapted to our locality. It is, therefore, highly important that an intelligent interest be aroused looking toward the conservation and improvement of our native nut trees as well as the introduction of desirable varieties from other countries.

In order to study the whole situation with reference to the needs and possibilities of nut growing in Illinois, a general survey of the occurrence and distribution of native and introduced nut trees in this state is being made by the writer. Considerable valuable information has been very kindly furnished regarding the nut trees native to the state by Mr. R. B. Miller, State Forester, from his extensive records. Dr. L. H. Smith and assistants in the Soil Survey work in the College of Agriculture at the Experiment Station have been very helpful in listing the numerous genera and species of nut trees as they have located them in checking up on the flora in making up soil maps of the different counties. Colleagues in the Department of Horticulture have also added to our list of nut trees as they have observed them. An extensive correspondence among the members of the Northern Nut Growers Association, county farm advisors, and others interested in nut growing in the state has been of assistance.

It is hoped that we will be able to prepare a detailed county map of the state showing (1) the native range of the most important nut bearing trees, and (2) the most important areas where such trees are being successfully grown outside their natural range because of local conditions favorable for growth and fruiting. Much of this information is in process of tabulation and no definite conclusions can be drawn as yet in answer to all questions being asked.

A number of interesting facts have, however, been gathered and are here submitted in the nature of a progress report.

Nut bearing trees native to Illinois include the shell bark hickory, Hicoria laciniosa, [1](C. laciniosa Cy), the shag bark hickory, H. ovata, (C. ovata Cy), the mockernut, H. alba, (C. alba Cy), the bitternut, H. cordiformis, (C. cordiformis Cy), the pecan, H. pecan, (C. pecan Cy), the American sweet chestnut, Castanea dentata, the black walnut, Juglans nigra, the butternut or white walnut, J. cinerea, the beech, Fagus americana, (F. grandifolia Cy-Ag.)[2]. Smaller trees or large shrub like forms include the Chinquapin chestnut, C. pumila, and the American hazelnut, Corylus americana.

A number of hickory and walnut species hybridize rather freely. There are some excellent hybrid varieties showing indications of the pecan-shell bark hickory and the shag bark-bitter nut cross.

Nut bearing trees not native to Illinois, but varieties which are promising for planting in different sections, include the European filbert, C. avellana, the Japanese walnut, J. sieboldiana, the Chinese walnut, J. cathayensis, and the Japanese heart nut or flat nut, J. cordiformis.

Nut bearing trees not considered desirable for general planting in this state include the English (Persian) walnut, J. regia, and horticultural varieties of the so-called "paper shell" southern pecan. The former is not as hardy in wood or bud as the black walnut and is often killed back to the ground. This so-called winter injury

(1) Standardized Plant Names—1923—American Joint Committee of Horticultural Nomenclature-Salem, Mass., is here used as authority.

(2) The pignut (C. glabra Cy. C. porcina) is not included in the above list since (1) it is not commonly edible, and (2) it is probable that the true pignut is not found west of the Alleghenies although this is one of the hickory species which has been much split up by systematic botanists.

is probably due as much to unfavorable climatic conditions found in Illinois during late summer and fall as to low winter temperatures. The southern varieties of the pecan are often winter killed at the tips. In favorable seasons they will grow vigorously but seldom mature any nuts. Trees growing in Pulaski County, in extreme southern Illinois, bear occasional nuts but they are not well filled out and do not ripen.

General Considerations:

Many people do not realize that nut varieties do not come true to type from seed any more than do apples. Like other fruit trees, therefore, nut trees have to be propagated by budding or grafting. Seedling trees of doubtful value will result from planting of nuts no matter how desirable were the nuts. These trees will very seldom produce nuts as good as the parent and will, if they bear at all, be very slow in beginning. Because of this difficulty it is desirable to grow named varieties, propagated by reputable nurserymen, or to work over seedling trees with scions or buds with stock of a named variety.

Nut growing is comparatively recent and few nurserymen have devoted much attention to the propagation of named varieties. Many nurseries show photographs of superior nut varieties in their catalogs but list for sale practically nothing but seedlings. This is unfortunate in that it is disappointing and expensive for the purchaser to buy trees and care for them with the mistaken idea that he is getting good varieties.

Nut varieties worthy of general propagation and distribution must have certain valuable qualities. First of all the parent tree should be healthy and vigorous with no inherent fault as to its growth habit. The ideal tree is a regular bearer and at least moderately productive. The nuts should ripen early and be of good size and easy to crack, with a fairly thin shell, with a fair proportion of meat to the amount of shell. They should be quite resistant to the attack of insects and diseases. Some chestnut hybrids in southern Illinois, for example, are more resistant to the chestnut weevil than others

growing close beside them. The nut meats should be plump, of good color, rich flavor, and high quality.

Nut trees are more difficult to propagate than some other fruit trees and are, therefore, somewhat more expensive to buy. They should be planted at considerable distances apart, however. The initial expense involved will then be less than in planting an area to other fruit trees.

The Black Walnut:

The chief native nut tree of Illinois and the one to be most recommended for general planting is the black walnut. It is found growing wild throughout the length and breadth of the state where soil conditions are suitable. This species is adapted to a deep, moist but well drained soil such as is usually found on the so-called prairie types in Illinois. The soil must be rich for best results as the walnut is a very heavy feeder.

Its chief commercial importance has, in the past, resulted from the excellent qualities of the wood. This was used for many purposes ranging from fence rails to the finest cabinet work. Many trees have been cut for the lumber which should have been left to bear nuts.

Quite recently improved horticultural varieties of the black walnut, such as the Thomas and Stabler, have been found and are being propagated and sold for general planting. Considerable interest has been taken in the commercial possibilities of the black walnut, especially in southern Illinois. The late Mr. E. A. Riehl of Alton, the best informed man in the state on the growing of nuts, told the writer in 1924 that he secured ten pounds of meats to the bushel of Thomas black walnuts and could not supply the demand of the trade at a sale price of one dollar a pound. Commercial cracking machinery just placed on the market cracks the meats much more easily and cheaply than it was formerly done by hand.

The named varieties sell for higher prices because of their easier cracking quality, larger size and better flavor. The kernels of the black walnut are the most desirable for many purposes, especially in cooking and candy making. The black walnut is the only nut meat

which retains its full flavor upon cooking. The meat is more palatable and lighter in color if the nuts are allowed to cure properly and the husk is removed from the shell before it stains the meat a dark color. With the possibilities of increased consumption of nuts as food practically unlimited there is a bright future for the black walnut industry in this state.

A number of interested fruit growers in Union and Pulaski counties are top working seedling walnut trees, growing on hillsides or other out of the way places, to desirable varieties. They use a modified bark graft as a rule. It is usually safer to cut back the tree a few days before it is to be top worked and then to protect the young scion for a few weeks after grafting by bagging. It is desirable to support the vigorously growing scion the first season by tying it to a lath which has been fastened to the stock. Black walnuts begin to bear early. The writer saw, in Williamson County in October, 1924, a grafted tree of the Thomas variety at four years of age bearing thirty-nine nuts. (Plate 1, Fig. 1.) The species is well known as a long lived tree, and properly cared for it should increase in productivity annually for many years.

The Butternut or White Walnut:

This species is found in all parts of the state though not as commonly as the black walnut. It will grow on a variety of soils but succeeds best when planted on a rich, well drained, gravelly loam. It has been found locally in ravines and along streams where the soil is loose. Compact soils are not favorable for its growth.

The tree is much smaller in size than the black walnut, not as healthy or vigorous and varying greatly in productiveness. The nut has somewhat the same qualities as the black walnut with a rough thick shell, rather more difficult to crack. Some people like the flavor of the meat better than that of the black. Promising varieties originating in the East, such as the Manchester, should be tried out under our conditions.

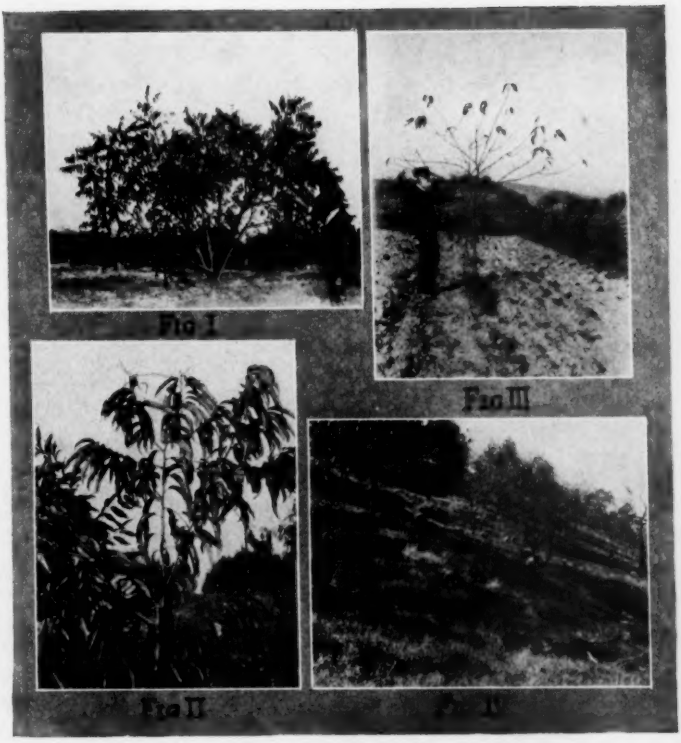


PLATE I.

Fig. 1. Thomas Black Walnut four years old bearing 39 nuts.
Fig. II. Chestnut graft (Boone variety) bearing same season.
Fig. III. Fuller Chestnut five years from graft bearing 31 burrs.
Fig. IV. Sheep, bluegrass and chestnut trees, Riehl Homestead, Alton.

Japanese Walnut Including the Heart Nut:

The Japanese walnuts have been introduced into various sections of the state especially through the central and southern counties. They are characterized by a rapid growth, beauty of form and foliage and early bearing. It is claimed that they are hardier than the black walnut.

Mr. C. A. Reed, Nut Culturist for the United States Department of Agriculture, highly recommends the Heart Nut as a promising sort for Illinois. The nuts are medium sized, distinctly heart shaped, with a thin shell and a kernel of good quality. They crack easily with one tap of the hammer and the kernel can often be removed entire from the shell. The Lancaster is considered one of the best varieties. (Plate 3, Fig. III.) The other type, J. sieboldiana, is a smooth shelled nut resembling the butternut in shape. It is superior in some respects to the butternut but has not as yet shown sufficient promise for general planting, although it has been fruited by Mr. Riehl at Alton.

The Chinese Walnut:

This nut is being grown experimentally in the eastern and northern states. It may prove hardier than the Persian (English) walnut and take its place as a commercial sort for this state. The nuts are said to be very large, with a shell somewhat midway in thickness between the English and black walnut. The kernel is reported to have a fine flavor. We are attempting its culture in the state.

The American Sweet Chestnut:

The chestnut is native to the state, being found in Olmstead, in Pulaski County as reported by Trelease[1]. It is reported from other counties mostly in central Illinois though it is probable that there are no other native stands of this species. It succeeds best on a well drained soil on sunny ridges, even in rather dry and rocky situations. It will not grow in wet soil or in soil under-

(1) Trelease, Wm., Trans. Ill. Acad. Sci., 10:1917, 143-145.

lain with hard pan. Limestone soils are not desirable. Chestnut trees, blue grass and sheep make an excellent agricultural combination. (Plate 1, Fig. IV.)

It grows rapidly to a large tree and produces large crops of nuts early. In the fall of 1924 Mr. Riehl showed me a young chestnut tree of the Fuller variety, five years from the graft, which had produced thirty-one burrs, three nuts to the burr. Chestnut trees in southern Illinois at the Endicott homestead near Villa Ridge were coming into profitable bearing at six years of age. Mr. R. B. Endicott told me in 1917 that his three largest trees of the Boone, Blair, and Riehl varieties had made an average for the last four years of better than one hundred pounds of nuts per tree. They were then eighteen years old. Last fall, 1924, Mr. Endicott told me that he was harvesting about 160 pounds per tree. At the wholesale price of thirty-five cents per pound, on the Chicago market, his gross profits last year were over fifty-five dollars ($55.00) per tree. The chestnut blossoms late in spring and is seldom caught by a late frost. Mr. Endicott's trees have failed to bear a crop but one year since planted.

The varieties mentioned are hybrids between the Japanese and native species. The Fuller variety first propagated by Mr. Riehl is superior to these in the quality of its nut.

The only objection to the more general planting of these improved varieties of chestnuts in Illinois is that they may be at some future time infected with the chestnut bark disease which is fatal to the tree. As far as we know, however, this disease is not present in the sections east of us and there are very wide barriers to its western migration. There is no reason for importing other varieties since the Boone and Fuller are equal to any being grown in the East.

The Chinquapin Chestnut:

This species grows locally, especially in southern Illinois, under similar conditions to the American Sweet Chestnut. Usually of shrubby bush-like growth, it has some advantage over a larger tree in matters of propa-

gation. It bears a much smaller nut than the native sweet but it comes into bearing very early and the nuts are of excellent quality. It makes an ornamental little tree and pleases the children to have one for their own.

The Pecan Hickory:

In the minds of many people the pecan is placed first from the point of view of the quality of the nuts produced. Native to Illinois, the pecan is found growing abundantly all over the state where conditions are favorable. It is quite generally restricted to bottom lands especially over southern and southeastern Illinois, along the Kaskaskia and Ohio Rivers and their tributaries. Other productive stands are found along the Illinois River at least as far north as Peoria County and along the Mississippi through Jo Daviess County. It is most common on bottom land subject to overflow at the time of the spring floods. This fact may partially explain the general distribution of the pecan through the dispersal of the nuts by flood waters. It has been found, however, that pecans will grow well on higher land. Since the pecan has a long tap root, soils underlain with rock or hardpan, which comes near the surface, must be avoided in planting.

In Illinois, varieties only of northern or local origin should be considered for planting or top working on seedling trees. None of the so-called "paper shell" or southern pecans are sufficiently hardy to recommend them. Mr. S. W. Snyder of Center Point, Iowa, a recognized authority on the propagation and care of nuts, writes me that "nature planted pecans in Iowa up to the forty-first degree of latitude". Such varieties native to Iowa include Witte, Campbell, and Oberman. Mr. Snyder writes that "these varieties while not so large as those found growing farther south, yet are large enough to be desirable, and when it comes to quality, freshness of cracking and thin shells they cannot be surpassed by any." Mr. Riehl believed that pecans will not be hardy and productive in Illinois as a commercial proposition north of the thirty-ninth degree. Alton, Mr. Reihl's home, is just south of this line.

It is true that north of Alton in Calhoun County, native pecans are common, grow vigorously, and bear well some years. The late frost last spring cut down the crop materially. This often happens in that section. However, many excellent varieties originating in southern Indiana can be planted with fair promise of success in southern Illinois, south of the thirty-ninth degree of latitude. These include the Niblack, Busseron, and Posey. While not as large as the southern types, these varieties have a fairly thin shell of excellent cracking quality with plump kernels of rich flavor. The Posey is said to be the easiest of the three to crack and is of good size.

The Shagbark Hickory:

This species is the most valuable of the hickories for Illinois planting excepting the pecan. It is found well distributed over the state, sometimes on low lying sandy loams along the river bottoms. It is also found commonly on the rolling uplands, especially on the sides of the hills, associated there with the shellbark. This soil type is commonly known as yellow gray silt loam on undulating timber land. The tree is very promising for selection and improvement. The nut varies greatly in size and shape and cracking quality. (Plate 2, Fig. II.) Some strains have exceptionally thin shells. The varieties Hales and Vest are highly recommended.

The Shell Bark Hickory:

Sometimes called the big shell bark or King Nut, this species is found native over the state at least as far north as Peoria County. It more often prefers the low lying river and creek bottoms, and like the pecan does not suffer from an occasional overflow if not too long continued. The tree and nut (Plate 2, Fig. III) are both larger than the shagbark. The nut is thicker shelled and the kernel, though good in quality, is not so much sought after as the shagbark. The Weiker variety is probably a cross between the shagbark and the shell bark and is a promising one.

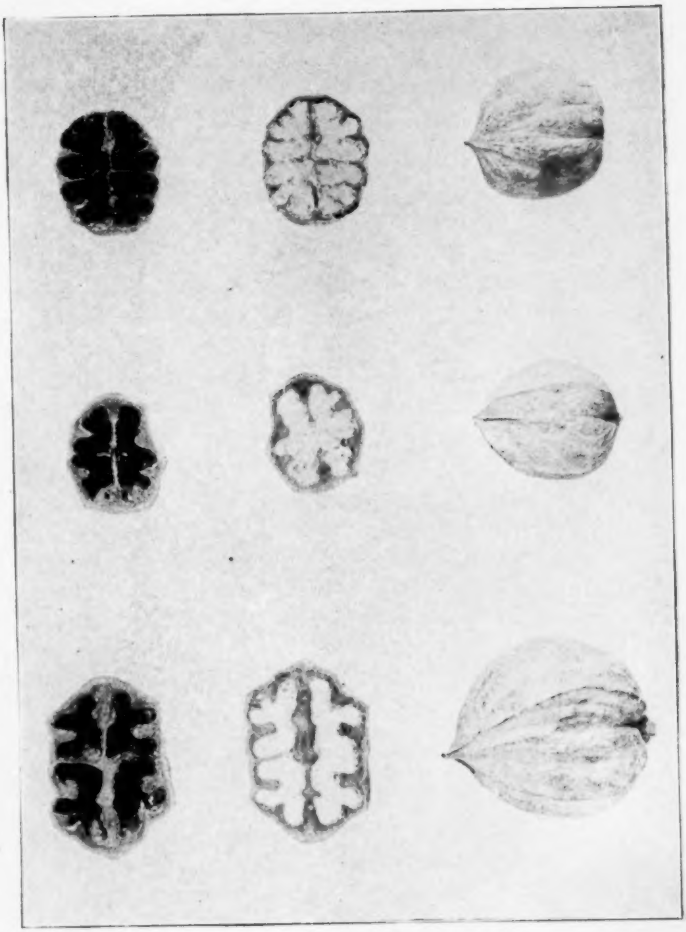


PLATE II.

Fig. I. Upper row. "Laney." Shagbark bitter nut cross.
Fig. II. Center Row. Seedling—Shagbark Hickory.
Fig. III. Lower row. Seedling—Shellbark Hickory.

The Mockernut and Bitter Nut:

These two hickories are found growing quite generally over the state. They appear to adapt themselves to their environment, growing both in the lowlands and upland or prairie types of soil. The nuts are comparatively small and of little value for human food.

The bitter nut is chiefly valuable as a parent in hybridizing with the shagbark hickory.

The pure shagbark, while it bears nuts of fine flavor, is of such slow growth that it is recommended by J. F. Jones of Lancaster, Pennsylvania, (one of the best known nut nurserymen) to plant hybrid varieties from the shagbark-bitter nut cross. He says that these hybrids are rapid growers and bear excellent crops in six years from grafts. He recommends the Beaver variety from Pennsylvania, the Fairbanks from Iowa and the Laney (Plate 2, Fig. I) from New York.

The American Beech:

This species is found widely distributed, often being found in the prairie as well as the dry sandy regions. It is a common tree on high ground, although it is sometimes found at much lower levels. It has not been commonly thought of as a nut bearing tree although the nuts are of excellent quality. The nut is too small. It is possible that it may be improved. It is understood that the tree does not take kindly to domestication and special pains are necessary in transplanting.

The American Hazel:

This species grows wild throughout the state. A moderately rich, well drained soil and freedom from mild periods in winter and no late frosts are requirements for the successful culture of the hazel. Both staminate and pistillate catkins develop in fall and are ready to open with the approach of mild weather in winter or early spring. The planting of different varieties to provide cross pollination is essential. No desirable named varieties have been originated from the native species worth propagating, excepting possibly the Rush. From the

European species, however, as well as from hybrids of the American and European species, a number of excellent varieties have been secured showing promise for commercial culture in Illinois. Judge Potter of Marion is growing the Dorrton variety of French origin successfully. (Plate 3, Fig. II.) Other varieties worth trying out are the Barcelona, Daviana, DuChilly and Globe.

Where Nut Trees May Be Used to Advantage:

Nut trees of suitable species and varieties should be more generally planted in Illinois.

(1) On otherwise waste land. There are many areas especially in southern and western Illinois which are not easily or profitably cultivated. Where the soil is suitable, it is highly desirable that chestnuts, walnuts, and hickories be planted there. Soil erosion is a serious factor in limiting the planting of agricultural crops in southern Illinois. Nut trees on rolling ground often effectively prevent soil erosion and bring in highly profitable returns. Reforestation with nut trees bearing edible nuts is highly commendable. The trees may be used primarily for their timber while the nuts will be worth considering as a side issue.

(2) As a Commercial Proposition: Commercial plantations of chestnuts, walnuts, and perhaps pecans in southern Illinois should be tried out. Chestnut orchards in Villa Ridge cultivated like fruit trees, and in Alton on steep hillsides (Plate 1, Fig. IV) have already proven a commercial success. At Marion are the beginnings of a commercial planting of pecans, chestnuts, and black walnuts. J. F. Wilkinson of Rockport, Indiana, a nurseryman of considerable experience in propagating nut trees, believes that orchards of nut trees interplanted with apples and other fruits will be profitable and more permanent than where no nut trees are used. Experimental evidence not as yet available will be necessary before recommendations can be made.

(3) Trees for the Home Grounds: There are various places about the home both in the city and country where shade trees might be both useful and ornamental. Why

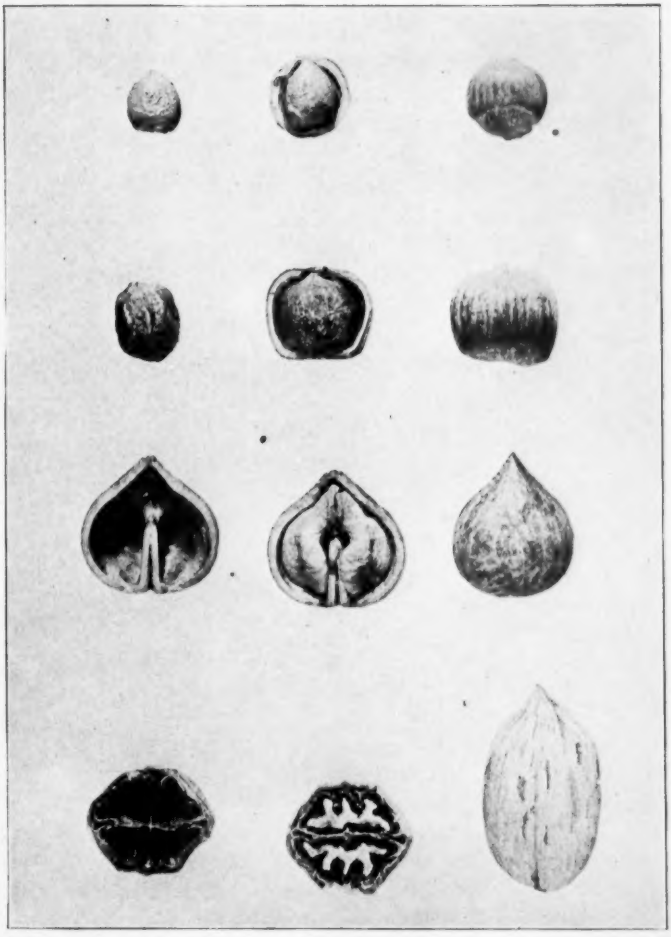


PLATE III.

Fig. I. (Upper row). Native Hazelnut.
Fig. II. French Filbert, variety "Dorrton."
Fig. III. Heart nut, variety "Lancaster."
Fig. IV. (Lower row.) Hickory-Pecan Hybrid, variety "Rockville."

should we not start now increasing our potential food supply? The future will show its need.

(4) As Roadside, Street and Park Trees: Little attention has been paid to the wonderful possibilities for using nut trees where the soil and site are suitable for beautifying our roadsides, streets, and parks with various hardy species, both the best varieties of the native as well as the introduced species. In Michigan nut trees are being planted along the highways. We should do this in Illinois.

OUTSTANDING FEATURES OF THE PLANT DISEASE SITUATION IN ILLINOIS DURING 1924

L. R. Tehon, State Natural History Survey, Urbana

During the past four years the Botanists of the State Natural History Survey have kept under observation the progress of disease infection among crop plants. The present paper presents a summary of the observations made during 1924, and is the fourth in the series.

In 1924 crop-plant diseases were prevalent, as usual, in epidemic form, and caused considerable losses. The unusual weather conditions favored the development of certain diseases in the north while inhibiting them in the south; and for the same reason several diseases, usually mild, took on serious proportions.

WEATHER SUMMARY

Weather begins to influence crops, and crop diseases, in the fall of the previous season. Certain crops are planted then, to winter in the soil and bear fruit the following summer. These crops are susceptible to the attack of fungi or bacteria from the time they are planted; and these incipient infections may result in the death of disease-weakened plants during severe winter weather without the fungus manifesting itself in the usual way. The fungi are as susceptible to unfavorable weather as are their hosts, and the fall and winter weather may be depended upon to determine in a large degree the abundance of infective material at hand in the early spring months.

September, 1923, while nearly normal for precipitation and temperature, had a very low maximum temperature and a great number of cloudy days, and there was a frost on the 14th—very early in the season. October was a rather cool month with rainfall above normal, which delayed wheat seeding. November was a month of rather mild temperatures with less than the normal rainfall, though the lack was less than an inch generally. December was the warmest of its kind since 1889, with very little snowfall but the greatest rainfall since 1895, except north and west of the Illinois River. January, 1924,

marked a change from the preceding mildness, it being colder than any January since 1918, low temperatures ranging from -4 degrees in the south to -25 degrees in the north. Precipitation was slightly greater than normal. February, with a departure of 2.8 degrees above the normal, was a mild month with, however, frequent snows totalling 10 to 19 inches north and west of the Illinois river. March was cold, cloudy, and with frequent snows—snowfall averaging for the state 2½ times the normal amount. Sunshine was only about half the usual. April was mild and dry, with a temperature 2.2 degrees above the normal and rainfall 1.23 inches less than the average. May was a very cold month—5.8 degrees below normal—but precipitation was nearly normal. June, while not cold, was 1.5 degrees cooler than normal, and very wet, having 2.97 inches of rain more than usual. July was 4 degrees colder than usual with 0.1 inch less of rain than usual. August was normally warm, and heavy local rains covered the north half of the state. September was another cold month—5.1 degrees below normal—although the latter half of the month warmed up as a prelude to the pleasant October which followed. There was a great deficiency of rainfall north and west of the Illinois River, but elsewhere it was near normal.

PREVALENCE OF DISEASE

The common diseases of most crops were more nearly normal in prevalence than in 1923, but in several instances minor diseases, favored by local conditions, assumed serious proportions.

DISEASES OF FRUIT

Among apple diseases, bitter-rot, widely prevalent and serious in the south in 1923, was still more serious than in ordinary years with special centers of intensity in the extreme south. Its appearance in Pike and Adams county marks an unusual northward advance. Scab, the most prevalent of the apple diseases, was prevalent throughout the northern two-thirds of the state. It made its first appearance May 6 in Johnson County, but did

not become general until May 16—two weeks later than usual. Blotch infection, because of a lack of soaking rains, did not become general until after June 15. Twig infection and considerable fruit infection were its outstanding manifestations. It was generally prevalent farther north than usual, and seems to be getting worse there. Black-rot was more prevalent than a year ago, and was of considerable importance as a fruit rot. It had invaded twigs blighted a year ago, and from these spread to the new leaves and the fruit. Fire-blight, though now as usual relatively unimportant on all except a few very susceptible apple varieties, continued more prevalent than in the past and was even more prevalent than last year. It appeared in damaging severity mostly as a late blight on fruit. In the south, Jonathans and Transparents were badly blighted, while in western counties Willow Twigs suffered generally from body-blight. Blister-canker was slightly more prevalent than usual, in spite of the wet season, upon Ben Davis trees. Rust also was more prevalent, but was not seen as far north as last year. Its infection was mostly on leaves, but there was some fruit injury. Powdery-mildew, never common, appeared in a limited territory in the central-west of the state. Brown-rot, usually rare on apples, was common in small northern orchards following codling moth injury after the middle of July. Fly-speck was more prevalent in small orchards but was not general in commercial regions. Sooty-blotch was much more prevalent than usual, being generally abundant in western counties from Mercer in the north to Calhoun and Jersey in the south, and in the southern tip of the state. It was the most general attack of this disease ever recorded in Illinois. Two leaf-spots, due to Septoria and Coniothyrium fungi, were prevalent in western counties. Jonathan Fruit-spot was rare, undoubtedly because of the small Jonathan crop. In spite of the severe winter and backward spring, there was little frost injury seen.

Pear diseases were in general as bad, or worse, than a year ago. Blight occurred throughout the state, as usual, and was very serious even upon less susceptible varieties such as Garber and Kiefer. The Leaf-spot was prevalent through the central counties causing severe leaf-

spotting and some defoliation. Kiefer is apparently resistant to it. Scab, although of its usual slight importance, was more prevalent than usual, appearing especially in northeastern counties. Leaf-blight was less common than usual, and was seen only in Macon County. Here it appeared on pear fruit—a very unusual thing in Illinois. Black-rot was about as prevalent as usual on pears, causing, however, serious Fruit-rot in a small two acre orchard in Alexander County—the only record of serious fruit injury we have in the state. Rust on Pears was seen only in Hancock County. In Putnam County Scab injury was followed by Pink-rot while the fruit was still on the tree. The severely cold winter temperatures killed about half of the blossoms.

The Quince, which is not widely grown in the state, suffered chiefly from blight, which was on twigs, in Champaign County and in southwestern counties. The Leaf-spot was seen only in St. Clair County.

The Peach crop was seriously injured north of Carbondale by severe winter temperatures. Still, the diseases were generally more prevalent and severe than usual. The Bacterial Shot-hole was very much more prevalent than usual and occurred throughout the southern two-thirds of the state. It attacked the fruit and leaves of all varieties, but the Jasper and Newton trees were relatively free of it. Brown-rot was much less abundant than usual. It appeared early as a twig-and-blossom-blight and later as fruit-rot, but the small Peach crop prevented the usual serious injury. Leaf-curl was much less prevalent than last year, but was present in about the usual amount throughout the state and especially in a belt of counties just south of the center. Scab was less than usual, being limited to the extreme southern counties, where it resulted in the cracking and marring of fruit. Die-back was prevalent upon twigs weakened or injured by the cold.

The Cherry crop, which was not injured by the severe temperatures of January, suffered very seriously from the attack of Brown-rot throughout the northern half of the state. Compiled notes taken on the prevalence of this disease indicate 16 per cent of diseased fruit in commer-

cial orchards. Yet the crop was so abundant that the disease was of little significance. The Cherry Leaf-spot began to appear in southern counties about June 10, and before the summer was over became very prevalent in the north.

Plums did not suffer to any extent from the severe colds of January. Brown-rot, always a common malady, was especially prevalent north and west of the Illinois River. The Shot-hole was very much less common than in the year previous and caused little damage. The Bacterial Shot-hole, as on Peaches, was much more prevalent and next to Brown-rot in importance. It occurred throughout the state, but was most serious north and west of the Illinois River. Black-knot was as prevalent as usual, with a region of severe attack in a few central counties. The Leaf-curl of Hortulana Plums, caused by *Exoascus mirabilis* Atk., was common in eastern counties, and was found in McDonough County—the first record of its occurrence in western Illinois.

The Grape crop suffered some from early frosts, but the great reduction in fruit setting was due to successive rains during the blossoming period. Black-rot became prevalent after the first of July, causing considerable fruit-rot; but it was unusually rare as a Leaf-spot. Downy-mildew was the most important disease, greatly injuring leaves throughout the state after the middle of July. Powdery-mildew was more prevalent throughout the central counties than last year, but was not serious. Anthracnose was prevalent and often severe in Madison County; and a Chlorosis, apparently associated with root worm injury, was seen in Cass County.

On the Blackberry and Dewberry the Orange Rust was slightly more prevalent than usual and extremely important locally, while Anthracnose was prevalent as usual, though apparently a little less serious.

Among the Raspberry diseases Anthracnose appeared more prevalent than usual and was the most serious of these diseases. The Leaf-spot was especially abundant in northwestern counties, and Cane-blight was common in some large plantations in the same district. Powdery-mildew, while rather more prevalent than usual in the

north half of the state, was of slight importance. Virus diseases such as Mosaic and Leaf-curl were widely prevalent, and the important Bramble-streak was found in all berry-growing sections.

Gooseberry Anthracnose was no more prevalent than usual but was serious locally north of the Illinois River. The Leaf-spot was abundant this seaon in the northwest, while in 1923 it was abundant in the southern tip.

The Currant Leaf-spot was prevalent, but not severe, in the north central counties.

CEREALS

Corn was subject, as usual, to severe Root-rot injury, which was increased considerably by the unusual abundance of the Southern Corn-root Worm. The Black-bundle disease was the most important of the identifiable Corn diseases, occurring throughout the state and being especially severe in the central counties. The Diplodia Ear-rot became prevalent late in the season and was an important contributor to the poor seed harvest. Smut was especially a disease of the ears, representative counts over 1385 acres showing 4.6 per cent of the ears smutted. Brown-spot, though more prevalent than usual, was still a minor disease with only rare instances of damage. Rust was much more extensive in its distribution than hitherto known in the state but was probably of little consequence.

Among Wheat diseases Leaf-rust was, as usual, the most important, although slightly less prevalent than usual. Stem-rust, though more abundant than usual, was decidedly less prevalent than in 1923, appearing later, and doing very little damage. Stinking-smut was apparently much reduced in importance from a year ago, although it was still sufficiently abundant in the harvested crop to result in a considerable dockage. Loose-smut was more widely prevalent than usual, but the infection was noticeably smaller than usual. Flag-smut was prevalent in the districts where it had previously been found. Scab did considerable damage in many localities, particularly in the northern half of the state. Anthracnose was especially prevalent in west central counties. Speckled Leaf-blotch was prevalent throughout the state, except in a

few extreme northern counties. Powdery-mildew, rarely seen in Illinois, was severe locally in Lake and DuPage counties; and Ergot, also rarely seen on Wheat in Illinois, was generally prevalent in the second tier of counties south of the northern border. Wheat plants were found parasitised by a tiny mushroom, *Marasmius scorodonius,* in Knox County. Two physiological troubles were prevalent. A Strip disease was very prevalent in southwestern counties, affecting leaves from about June 5, to harvest; and a blast, similar to oak blast, was observed in Carroll County.

Oats suffered most severely from Smut, the infection reaching as high as 55 per cent in some shocks, with an average for all cases observed of 5.7 per cent. Crown-rust was of very little importance, although the attack was quite general in northern counties. Stem-rust, of little significance on wheat, became unusually prevalent in Oats, and 10 per cent infections were not unusual in the north half of the state. Scab, though more than usually abundant, was of little significance except in a few counties in the upper Illinois valley. Halo-blight, not hitherto common in Illinois, was found in 12 widely separated counties reaching from Union county in the south to Carroll county in the north. Blast, a physiological disease of considerable significance every year, was especially prevalent in the extreme north where it seriously curtailed the yield. Anthracnose was of slight importance generally although prevalent northward. Leaf-spots due to Helminthosporium were prevalent in 3 southern counties, while another Leaf-spot, caused by *Scolecotrichum graminis,* not hitherto known to occur in Illinois, was found in Jasper county.

Rye, which is widely though not extensively grown in the state, did not suffer seriously from any one disease, but the total effect of the disease was considerable. Leaf-rust was prevalent throughout the state, and Stem-rust was common in a few northern counties. Smut was unusually light, and occurred farther north than in 1923, while Ergot was generally prevalent north and west of the Illinois river. Scab and Anthracnose were both prevalent in the northwest, and Powdery-mildew

was found in DuPage county. The mushroom, found attacking wheat, was also found on Rye in Carroll county.

Barley, which is grown intensively only in the northern third of the state, suffered rather more than usual from most diseases. Loose-smut was prevalent throughout the barley region, causing appreciable losses in almost every field. Covered-smut, usually rare in Illinois, was seen several times and one instance of a 7 per cent infection was recorded. Scab was much more prevalent than usual throughout the northern counties as was Stripe, the Stripe diseases being second only to Loose-smut in importance. Leaf-rust, though slightly more prevalent than usual, was not serious; and Stem-rust, though much more prevalent than usual, seemed less severe even than the Leaf-rust. Anthracnose attack was not so general as the other diseases, being largely limited to the north eastern counties. Ergot was prevalent over a wider area than heretofore, but the individual infections were much less serious. Spot-blotch, not often seen in Illinois, was found in three northern and one southern county. Infections of Powdery-mildew were found for the first time on barley in the state, the disease being prevalent in the north eastern corner. The mushroom mentioned in connection with wheat and rye was found on Barley in DuPage County.

A Leaf-spot, due to *Piricularia grisea,* was found generally on Millet in the southern half of the state; and Scab, Anthracnose, and an Helminthosporium Leaf-spot were seen on Spelt in Will County.

FORAGE CROPS

Timothy was subject to but three diseases of any importance. Stripe-smut was found only in Jasper County; Stem-rust was prevalent throughout the north half of the state; and a Leaf-spot, caused by *Scolecotrichum graminis* Fckl., was prevalent and injurious north and west of the Illinois River.

Alfalfa diseases were unusually numerous. Yellows was prevalent everywhere but was especially abundant in the north. The Pyrenopeziza Leaf-spot was found in

the state for the first time, causing slight damage in Will County. Three other Leaf-spots, each of considerable importance, were found in serious quantities, and are discussed especially in a separate paper.

Clover was covered, as it has been for three seasons, with Powdery-mildew; and a Cercospora Leaf-spot was prevalent in the central counties.

Soy Beans, especially in the central part of the state, suffered from Bacterial injury, and Cow Peas were often lightly infected with Leaf-spot.

TRUCK CROPS

Potatoes suffered from the usual diseases. Scab was prevalent throughout the state and especially abundant in northern counties. Early-blight was the most important Leaf disease, being very prevalent north and west of the Illinois River. Black-leg was unusually common in the southwestern potato district. Late-blight, very rarely seen in Illinois, was serious in McHenry County, and the Rhizocotonia disease was also prevalent and serious northward.

Tomatoes suffered generally from Mosaic and from a Wilt, the cause of which is not known. Early-blight was especially prevalent northward, and the Leaf-spot, the commonest disease in the state, was especially severe in the northwest.

The Egg Plant suffered considerably in the Peoria and Chicago districts from the Phomopsis Leaf-spot and Fruit-rot.

Cabbage Yellows was not reported once during the season although it must have been prevalent; but Black-rot was very common and very severe in the north half of the state. Club-root was present in Kane and Cook counties and a Leaf-spot, caused by *Cercospora bloxami*, was seen occasionally in the northwest. Cauliflower suffered somewhat from Black-rot in LaSalle, Will, and Cook counties.

Beans had four serious diseases. Anthracnose was of considerable importance in counties along the Illinois River, while Rust was prevalent in the south half of the state. Bacterial Blight was widely distributed, causing

leaf spotting throughout the northern counties and serious pod injury in Massac County. A Cercospora Leaf-spot was seen in Shelby County.

Peas appeared to suffer from diseases in the north half of the state especially. The Septoria Leaf-spot was prevalent in the extreme north, and the Mycosphaerella Pod-spot was generally serious in northern counties. Powdery-mildew attack was seen only in DuPage County.

Two diseases of Lettuce were reported. Septoria Leaf-spot was prevalent especially in northeastern counties, and Downy-mildew was found in Stephenson and Lee counties.

Beet and Swiss Chard were generally subject to the effects of the Cercospora Leaf-spot, although the disease appears to be generally less abundant on the latter. The Phoma Leaf-spot was present in scattered areas in Cook County.

Asparagus Rust was prevalent in the usual amount throughout the state; but there was an increase in the amount of Anthracnose; and a Pink Mold, caused by Botrytis, appeared in severe quantities in Alexander, Union, and Adams counties.

Okra was subject to a Leaf-spot, caused by *Phyllosticta hibisci*, in Jackson and Alexander counties.

The Ramularia Leaf-spot of Horseradish was seen in Cook County and the Cercospora Leaf-spot was prevalent in the west. White Rust was seen in Adams County.

Parsnips were generally affected by the Cercospora Leaf-spot in the north; Carrots suffered especially from the bacterial Soft-rot, and Celery from the Cercospora Leaf-spot in Peoria County.

Onions in Rock Island County were affected with the Cleistothecopsis Black-spot. Peppers in Alexander County were affected, though slightly, with an Alternaria Fruit-rot.

Diseases of Cucurbits were prevalent and often severe in all commercial districts. Watermelon Wilt is estimated to have caused a loss of 15 per cent of the crop, yet it was less abundant than usual. Anthracnose was most severe on Watermelons, occurring in all parts of the state and doing considerable leaf and fruit injury;

on Cantaloupe it was equally prevalent but less serious in its effect; and on Cucumbers it was serious locally in the southern tip of the state. Bacterial Wilt was very severe in all but the most northern counties on Cantaloupes, Cucumbers, and Pumpkins, causing great losses in many fields. The Angular Leaf-spot was also much more prevalent, though not extremely injurious, in a few northern counties. Mosaic was extremely prevalent on Cucumbers, but less so on Cantaloupes.

OTHER CROPS

The recent development of cotton culture in southern counties calls attention to possible cotton diseases. The Bacterial Leaf-spot and Boll-rot is already present and prevalent, and constitutes the most important of the diseases thus far observed. It was found in Saline, Union, Alexander, Pulaski, and Massac county fields during mid-season as a Leaf-spot and later as a Boll-rot. Two other Leaf-spots were observed to be prevalent, one due to a Cercospora and the other to a Phyllosticta.

Sunflowers, though not generally grown, have a local importance. Rust was found attacking them in three southern counties, and a Septoria Leaf-spot was prevalent also in the extreme south.

LICHENS AND SYMBIOSIS

W. B. McDougall, University of Illinois

When Schwendener announced in 1867 that the gonidia of lichens are algae and that a lichen is, therefore, not a single plant but a group of plants, the idea met with instant and prolonged opposition. Nylander, who was the foremost lichenologist of the time, never accepted the theory and wrote very bitterly against it. One of the chief reasons for the opposition seems to have been that the systematists were afraid that the components of lichens would be distributed among the fungi and algae and the group of lichens as a systematic subdivision of the plant kingdom would disappear.

The distribution of lichen-fungi among the other fungi is, of course, perfectly logical from the systematic point of view, and at present, after more than half a century has elapsed since the announcement of the dual nature of lichens, a few workers in this country are attempting to accomplish it. The lichen-fungi differ so greatly in vegetative characters from the other fungi, however, that a classification which maintains them as a distinct group is much more convenient and usable than one which distributes them among the already enormous numbers of other fungi. For this reason, for most botanists there will probably always be a distinct lichen group, however illogical it may seem to the systematists.

Some of the workers who have considered it advisable to classify the lichen-fungi among other fungi have contended that a lichen is simply a fungus and that they are classifying lichens among the fungi. It will be profitable, therefore, to consider for a moment the use of the term lichen. When the word lichen was first used, of course, it was thought that the lichens were single plants like liverworts. In fact they were at one time classed with the liverworts in one family. The discovery of the dual nature of lichens by Schwendener, however, demonstrated that the things called lichens are comparable to insect galls, mycorhizas, root tubercles, and other sorts of galls, in that they are produced only through the intimate parasitic association of unlike organisms. This being the case,

it is not logical to apply the term lichen to either of the organisms concerned. A fungus is a fungus and an alga is an alga, and it takes the two together to make a lichen. A lichen-fungus without an alga will never grow up to be a lichen. Usually it will not grow up at all. In any case, however, it is entirely possible to have a lichen-fungus without algae, but we can no more have a lichen without algae than we can have a mycorhiza without a root. (One exception to this statement has recently come to light in the case of Rodobacteriophora in which there are purple bacteria in place of algal symbionts. The principle involved is the same here as in other lichens, however, and the force of the argument is not diminished by this exception.[1])

The objection has been made that unless we consider the lichen-fungus to be the lichen it will be necessary to invent new names for all of the lichen-fungi in order to distinguish them from the names used for the lichens. Probably certain systematists who are overly fond of publishing new species names, with their own names following them, would be delighted with such a task. There is no need, however, for any such action. If we recognize, as we must, that lichens are comparable in many respects to the various kinds of galls, we can readily see that there is no need of a name for a lichen as distinct from that of the lichen-fungus. The algae that are concerned in the make-up of a lichen ordinarily belong to well-known species which already have names, and there is no reason why the names by which the lichens are known should not be used for the other components. This in fact is what has been done, consciously or unconsciously, for the last half century. We do a similar thing in the case of many insect and fungus galls. We collect a gall from a popular tree and we say it is Pemphigus vagabundus on poplar. We understand perfectly that Pemphigus vagabundus is the name of the gall-forming insect but we use it also to designate the gall. Or we collect a black "knot" from a plum tree and we call it Dibotryum morbosum, although this is merely the name of the parasitic fungus. No confusion results from this usage nor is there any reason

(1) Uphof, J. C. Th. Purple bacteria as symbionts of a lichen. Science 61-67-1925.

for confusion from a similar usage of names in the case of lichens. It cannot be argued that the galls mentioned are very different from a lichen in that the entire host plant is not involved, for the difference is only one of degree. If an entire oak tree were greatly modified by a parasitic insect or fungus we would still call it a gall and would designate it in the same way that we do other galls. It should be reiterated that there can be no logical objection, unless it be that of convenience, against classifying the lichen-fungi along with other fungi, but we cannot call a lichen-fungus a lichen any more than we can call a mycorhizal-fungus a mycorhiza or a gall-insect a gall; we cannot say that lichen is a fungus any more than we can say that a mycorhiza is a fungus or that a gall is an insect.

The exact physiological relationship between the two components of a lichen is still very imperfectly known, although it has been studied and discussed for a very long time. Some writers have thought that a lichen represents a sort of partnership between the fungus and the alga, each partner supplying to the other certain necessities of life in a spirit of neighborly regard. Others have taken a somewhat opposite view and have painted the fungus as a culprit which has made a slave of the poor alga. Still others, getting back to a botanical way of looking at things, have in some cases considered the fungus as an ordinary parasite on the alga, or, on the other hand, have said that the fungus is diseased by the alga.

It is improbable that the physiological relationship between lichen-fungus and alga is exactly the same in all cases. It is reasonably certain, however, that in the majority of lichens the fungus obtains organic food from the alga, either as a parasite on the living gonidia or as a saprophyte on dead ones. Similarly, it is certain that the alga obtains water, at least, from the fungus, either directly or indirectly. The relationship has apparently reached such a balance that it is more or less normal for both fungus and alga and both can endure it, therefore, without suffering. This, however, must not be taken to imply a sort of reciprocity agreement under which each

party supplies something to the other. Rather each party takes all it can get from the other. In other words the lichen represents a case of double, or reciprocal, parasitism.

This rather nicely balanced relationship is not vitally different from the social relationship between the green plants and the fungus flora of a forest, in which the fungi use organic food that has been elaborated by the green plants and the green plants use food materials that have been made available through the activities of the fungi. In this case, however, the organisms concerned are not in actual, intimate contact and they derive materials only indirectly, rather than directly, from one another.

Now symbiosis means the living together of two or more unlike organisms. It includes all such cases regardless of their physiological relationship.[2] There can be no question, then, of a lichen not representing a case of symbiosis. When the organisms concerned are in actual contact, as in a lichen, the symbiosis is said to be *conjunctive,* while those cases in which the symbionts are not in actual contact, as the green plants and fungi of a forest community, represent *disjunctive* symbiosis. When there is no food relationship between symbionts, as in the case of an epiphyte on a tree, the symbiosis is *social,* while if there is a food relationship it is *nutritive.* Nutritive symbiosis is further subdivided into *antagonistic,* to include cases in which only one symbiont, or at least not all of them, derives benefit, such as ordinary parasitism or disease, and *reciprocal,* to include cases in which more than one symbiont derives benefit from the relationship. From these remarks it will be readily seen that if the physiological relationship between lichen-fungi and algae (gonidia) is substantially as described above, a lichen represents a case of reciprocal nutritive conjunctive symbiosis.

(2)For a more detailed discussion of the use of the term symbiosis see McDougall, W. B. The Classification of Symbiotic Phenomena. Plant World 21: 250-256. 1918.

PHOSPHORUS AND THE EARLY MATURITY OF PLANTS

CHARLES A. SHULL, UNIVERSITY OF CHICAGO

INTRODUCTION

Ever since the Earl of Dundonald found that alkaline phosphates were of importance in the nutrition of plants, the element phosphorus has been considered necessary for plant growth. All subsequent research has confirmed the view that phosphorus is essential to the complete nutrition of plants, and for a long time phosphorus has been included among the elements needed for a complete fertilizer in improving soil fertility. In summarizing the value of phosphates in plant growth, Russell calls attention to the increased growth of the root system in lateral and fibrous roots, and the better storage of food in root crops provided with an abundance of soluble phosphates. He mentions the influence of this element in increasing both straw and grain production, its connection with nuclear processes in cell division, its relation to the normal transformations of starch, and its importance in determining the quality and feeding value of crops grown on the soil.

In addition to these effects, it has been observed that phosphates hasten the maturing processes, thereby hastening the harvest of cereal grains by a few days. Nothing is said as to whether the grains develop bloom primordia at an earlier date in the presence of abundant phosphate supplies, and no observations are recorded as to whether the blooming time, or sexual maturity, comes on earlier due to phosphorus abundance. The hastening of maturity is said to be obvious only when a control plot is near by. The grain supplied with phosphates is then seen to turn golden yellow while the untreated plots are still green. The effect is likened to that of water deficiency which also hastens the coloring of ripening grains.

In some of the grains it seems that phosphorus is closely connected with the flowering processes. Thus Eckerson has shown for wheat that there are only traces

of phosphates in the very young spike, but that when sporogenous tissue begins to develop in the flower primordia, phosphate begins to enter the stamens and pistils in considerable quantity, mainly in the form of magnesium phosphate. The phosphates continue to enter the spore producing tissues until pollen grains and eggs have been formed. As the megaspore mother cell divides, and the functioning megaspore increases in size, the phosphate becomes very abundant in the embyro sac. With the development of the egg, maximum phosphate content of the embryo sac tissue is attained. Hooker has found an increase of phosphates in fruit spurs of apples at the blooming time, so that it is apparent that the use of phosphates in the building of nucleins, nucleoproteins, phospholipines, hexosephosphates, etc. is most rapid during the development of sex organs.

These interesting observations, however, do not show whether the presence of phosphorus in the form of soluble phosphates leads to an earlier formation of the primordia of the flower, or earlier attainment of sexual maturity (blooming) than in plants grown with deficient supplies of this element. It would be of considerable interest to know whether the earlier ripening of grains with phosphate supply is correlated with an earlier date of sexual maturity.

Some recent experiments at the University of Chicago with one of our lower plants, Marchantia polymorpha, indicate that this plant can be hastened through its life history to sexual maturity by strong applications of soluble phosphates. This paper gives a brief account of the experiments in which this effect was noted.

THE METHOD USED

Soils were obtained from the margin of the Forest Preserve at Thornton, Ill., in an area that had been burned over some years ago, and upon which Marchantia had been growing abundantly for some time. The free growth indicated that this soil was well adapted to the needs of Marchantia. At the same time, similar soil from unburned areas was obtained for control studies. The unburned soil differed in no essential respect from the

burned soil, but was occupied by trees and shrubs under which no liverworts were growing.

The burned soils were used in fertilizer tests to determine the effects of added nutrients on the rate of growth of Marchantia. A triangular series of pots was arranged, containing 21 cultures. To these pots varying amounts of phosphates, potash, and nitrogen fertilizers were added.

The pot at one apex of the triangle received enough sodium dihydrogen phosphate solution to give it the equivalent of 80 ppm of P_2O_5. The succeeding rows received 64, 48, 32, and 16 ppm, and the row opposite the high phosphorus apex received no phosphate addition.

At another corner of the triangle, one of the pots that received no phosphorus was given potassium chloride solution equivalent to 80 ppm K_2O, and the succeeding rows 64, 48, 32, and 16 ppm, while the last row opposite the high potash apex received no potash.

Similarly the third corner pot received an addition of sodium nitrate solution equivalent to 80 ppm of NH_3. The succeeding rows received 64, 48, 32, and 16 ppm, and the final row opposite the high nitrogen apex received no addition of nitrate fertilizer. This arrangement permitted observation of the effects of a single nutrient, of combinations of any two, and of various proportions of all three, upon growth, on the production of cupules, and upon the rate of attainment of sexual maturity.

RESULTS

The pots, including duplicate controls of burned and unburned soils, were sowed with gemmae of approximately the same age, and in about equal numbers, on April 20, 1922. The observations were extended over a period of a few weeks until sexual maturity had been attained by a number of the cultures.

(a) *Growth of thalli.*

The effects of the addition of the salt solutions soon became evident in the growth of the thalli. When the

young plants were nine days old, it was evident that R_1S_6, the pot which received 80 ppm sodium nitrate only, was the poorest culture in the entire triangle. The row of pots forming the right side of the triangle, in Figs. 1 and 2, showed a regular gradation in size of thalli from pot 6 to pot 21 at the apex, the latter being the best in the row, judging by size of thalli. As nitrogen supply decreased, and phosphate increased, the growth was very noticeably better.

Along the base of the triangle from pot 6 to pot 1, there was a larger difference between number six and number five than at any other point in the row; but pots 4, 3, 2, 1, seemed to be increasingly good, with rather small gradations.

On May 1 the best culture in the entire set was R_2S_1, or pot number seven, which had received 64 ppm K_2O, and 16 ppm P_2O_5. The best region of vegetative growth was represented by pots 7, 8, 9, 12, and 13, at the left end of the second and third rows from the bottom of the triangle.

(b) *Production of cupules.*

Cupules began to develop on certain cultures soon after the first of May, and observations were continued until May 22. The diagram shown in Fig. 1 indicates the order of appearance of gemmae in all of the pots where asexual budding occurred. The general region of the triangle to show cupule development was the potash corner, where four of the six pots with these organs are clustered. The first cupules to appear were on the plants receiving 80 ppm potash, without any other nutrients. The results suggest the possibility that potash may be specially advantageous to the plant in this asexual reproductive phase of its life history.

(c) *Attainment of sexual maturity.*

About May 10 it became evident that some of the plants were beginning to produce gametophores. As the receptacles developed their disks it was noted that all of them were antheridial. No females were developed

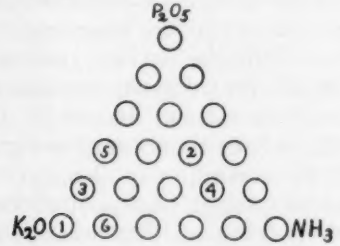


FIG. I. Order of development of cupules in Marchantia polymorpha.

during the course of these observations. Observations were made from day to day until May 22, at which time all but four of the pots showed at least the beginnings of gametophore development. The results on May 22 are shown in Fig. 2, in which the oldest receptacles are numbered 1, and succeeding stages with younger disks, 2, 3, 4, and 5. Those marked 5 were just visibly entering the period of gametophore development, and those marked 0 did not yet show the beginnings of sexual development. They were almost ready, however, as traces of such growth became visible on May 25. At this later date, ten of the cultures had full size mature receptacles, and of these eight were at the phosphorus corner of the triangle, pots 21 to 14, inclusive. The other two were pots number 7 and 9.

At the same time the controls, both on the burned over and unburned soils, showed the merest traces of sexual development in one pot of each duplicate, and the other pot of each control showed no sexual tendencies.

The results show very clearly the acceleration of the life history by means of soluble phosphate application, and the strong tendency toward development of sexual maturity, even in plants that did not show the most rapid vegetative growth.

DISCUSSION

The factors which cause plants to blossom and fruit are receiving much attention from plant physiologists at present. Appropriate carbohydrate-nitrogen ratios are thought to be favorable to fruitfulness, and high ratios

to lead to early maturity. Photoperiodism is known to control to a certain extent the blooming habits of many kinds of plants. Thus the various species of Xanthium which bloom at different seasons are controllable if one uses the appropriate relative length of day and night. Garner and Allard have found quite a number of plants that respond to certain day lengths by blooming promptly when the proper photo-period is provided. It has been observed, however, that other factors may sub-

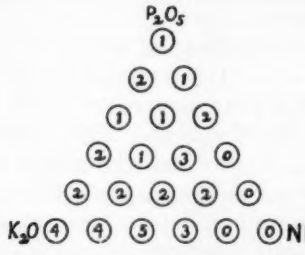


FIG. II. Phosphorus and sexual maturity in Marchantia polymorpha.

stitute for photoperiodic stimulation. Thus Gilbert has recently found that temperature greatly modifies the photoperiodic response of the Xanthiums. During the short day period of winter, Xanthium plants may be blossomed in three weeks from the seed if a temperature of about 25° C. is employed, but at 18° to 20° C., it will require several months to reach sexual maturity. During the long day period of summer, high temperatures will not cause blooming, but a shortening of the day does induce flowering.

Some of the lower plants have been found to be photoperiodic also; thus among the algae, Chara is known to fruit when it has the proper day length. And Marchantia has shown responses to different photoperiods, indicating that sexual maturity may depend in part upon conditions controlled by illumination.

Kraybill and Smith have noted that phosphorus supply has some influence upon the carbohydrate and nitrogen metabolism of the tomato, and it certainly has a greatly accelerating effect upon the development of sexual maturity of Marchantia.

It is evident that the control of blooming is not simple, and as yet cannot be expressed in terms of some common factor. However, a study of metabolism in all of these cases should throw much light on the causes which induce sexual development. It would also be valuable to know whether phosphorus will bring about earlier blooming in our common crop plants. In regions where length of growing season is a limiting factor on the kinds and varieties of crops produced, a difference of a few days in the time of blooming would be very important from the agricultural standpoint.

THE SIGNIFICANCE OF FOSSIL FOOTPRINTS

L. A. Adams, University of Illinois

The art of animal tracking is an old one that goes back to the time when man was young in experience. Obermaier in his book, "The Fossil Man in Spain," shows some drawings made by Magdalenian man in the Pileta cave at Mágdala, Spain. In these drawings ancient man himself has shown how he used these as an aid in the hunt. Since the art is not confined to man alone, it is probable that it is one of the oldest of the arts, developed through long generations of experience. A modern development of this old art may be seen in the literature that has grown up around the tracks of fossil animals. With the rise of geology and palaeontology, a new science has developed that consists of a study and interpretation of the footprints found in the rocks. Nothing appears in the literature to show that any significance was attached to them until after 1800, when a Mr. Duncan wrote about those found in the Bunter sandstones at Dumfries, Scotland. There is a record that these tracks were found about 1812 but the description was given by Mr. Duncan in 1828.

In America the first interest in tracks came through the activities of Professor E. Hitchcock of Amherst, a teacher of geology. He reports that the first notice made was through one Pliny Moody, who found tracks around South Hadley in 1802. Other discoveries were made but nothing was written until Hitchcock began his long series of contributions to the subject. He called the study Ichnology, and coined the word Lithichnozoa or Stony Track Animals. His first paper was published in 1826, to be followed by a long series of books and papers that were a real contribution to the new field of animal study through their tracks.

Since Palaeontology was comparatively new, it added very little to the study and Hitchcock had to depend largely on modern material for comparison. This led him into many errors of interpretation. He collected large numbers of specimens and classified them into classes, and gave the individual specimens scientific

names, giving the argument that it was just as justifiable to give a track a name as to name an animal from a bone. The fine distinctions that he made are interesting in their variation. In his "Ichnology of New England", he lists on page 74 the following classification of the tracks:—

Bipeds	31
Quadrupeds	55
Marsupialoid animals	5
Thick toed birds	14
Narrow toed birds	17
Ornithoid lizards or batrachians	10
Lizards	17
Batrachians	11
Chelonia	8
Fishes	4
Crustacea, Myriopods, and Insects	18
Annelids	8

Lull, in 1915, worked over the material then available in the schools and institutions of the east, and published in "Triassic Life of the Connecticut Valley" a new list of the tracks that differed materially from those of the early writers. Aided by a thorough knowledge of the fossil animals of the region and by the advances that had been made in Palaeontology and Comparative Anatomy, he was able to determine with accuracy most of the specimens studied and described by Hitchcock. He narrowed down the list to 104:

Parasuchia	7
Dinosauria	38
Reptilia	37
Amphibia	15
Doubtful vertebrates	3
Invertebrates	4

These summaries from the two authors are quoted to show the growth of the subject with time and research. The birds have been completely eliminated from the group and placed in their proper places as tracks of reptiles. This belt of the Connecticut River Valley is

famous for having supplied some of the most magnificent specimens known to the scientific world. Although only a small area ninety miles long and three miles wide, it must have been the home of thousands of early tetrapods who left their footprints on the shores of the brackish, Triassic sea.

The conditions under which tracks are made are very closely circumscribed, since the mud must be soft enough to take an impression, and at the same time firm enough to hold it after it is made. If the mud is too soft the form of the impression is lost, and if it is too hard but faint impressions will be made. After they are made they must be filled with silt, eventually submerged, and finally turned to stone. Sun drying with final submergence will produce the same effect, as sun tracks are frequently seen in rock formations.

The readers of tracks become as expert as any of the primitive trackers, using the impressions to fill in gaps where the actual remains of animals have never been found. This knowledge becomes very important since often these foot imprints are all that remain of the animals that once lived in a locality. The large fauna of the Connecticut Valley would never have been suspected had it not been for the remains left in this form. The information gained from such a study is somewhat varied in its details but certain facts can be determined with exactness. Questions as to size and weight are fairly well answered if the class of the animal is known. The relation of the feet to the size of the animal varies much, since an animal with large feet may weigh no more than one with a much smaller foot. A bear and an elk may weigh the same but the foot proportion is very different, and no estimate of the weight of the animal could be given without certain information regarding the group to which it belonged.

The question as to whether the form is bipedal or quadrupedal is usually answered, especially when the imprint of the tail is found. Since bipedal animals generally have a much smaller forelimb, the imprint shows this fact very clearly. Many quadrupeds show the imprints of all four feet, but some troublesome

forms have the habit of planting the hind foot exactly in the imprint of the fore foot, thus obliterating or destroying the definiteness of the track of the anterior limb. The habit of pointing the posterior limbs posteriorly causes some of the amphibians to make a track that appears to be going both forward and backward at the same time. The gait of the animals is usually plain, since hopping, running, walking, and jumping each leave a very distinctive form. The type of the foot is very essential in placing the animal in its proper group, as the phalangeal formula is usually diagnostic and is well known in a comparative way. Some of the reptile imprints give very definite indications of the exact toe formulas, thus making the identification more certain.

A short summary of some of the known tracks gives an idea of the amount of valuable information that has been obtained from this part of the investigations of the paleontologists. Walcott describes Annelid tracks from Pre-Cambrian and a number of Trilobite tracks from the Cambrian. In "Cambrian Geology and Paleontology" he has identified these tracks with the actual species that made them. Arthropod tracks are quite common since they live under conditions that make preservation possible. Hitchcock described a number in his work on the Triassic. The specimens shown to the members of the Academy of Science represent a series collected by the writer in a bed of Triassic shale near Flagstaff, Arizona. They were quite plentiful at this place, but because of the sandy shale their preservation was not so good, and much material had to picked over to secure a fair series of the forms represented. A preliminary study shows that at least three forms were represented in this Arthropod fauna and that they are of a type undescribed in the literature, in so far as the writer has been able to discover. It is hoped that a more thorough report and analysis may be made at a future meeting of the Academy. A study has been made by a comparison with the tracks made by some of the modern forms, but nothing definite has been arrived at, because of the limited amount of material available. That they

represent some kind of Crustacea seems certain, but no idea of relationship can be stated at this time.

The amphibia have left many imprints to tell of their presence in the coal measures and in other formations, and this is to be expected, since they lived around water where preservation was possible. Since the amphibia do not live around salt water, their tracks must be looked for in fresh water deposits. A number have been found in coal measures in different parts of the world. The earliest tetrapod track known is probably an amphibian. The form known as Thinopus antiquus was found in Warren County, Pennsylvania, and presented to Yale University where it was described by Marsh. It is frequently pictured in the textbooks. Judging from the marked peculiarities of the foot it is a very early type of tetrapod and seems to be in some stage of transition. Martin, 1922, describes a specimen that he collected in the bed of a small stream near Lawrence, Kansas. It consists of a series of tracks in good condition, so that some estimate may be made of the form making it. He has called it Onychopus gigas and gives its probable weight as four or five hundred pounds. The coal measures of Kansas have supplied many other specimens of amphibian imprints that have been fully described by Marsh and others.

The tracks of reptiles seem to be the most common of all and have been found in all the countries of the world. Different parts of America have supplied them in large numbers, while France, Germany, England and South Africa have contributed their share. It is interesting to note that in the reptiles, a considerable number of the tracks have been associated with the animals that made them. This is made possible by the extensive study of this class and the well known characters of their feet and the imprint that they would make.

A colleague tells of a region in Texas where Dinosaur tracks in rock slabs are used as watering troughs for chickens—which is rather a wasteful use of scientific material of this kind.

Birds and mammals have left few evidences of their presence in this form, since they spent very little time

around places where their tracks could be preserved. The wading and water birds do live under conditions where track making is possible, but very little evidence has been discovered of unquestioned bird tracks. The large number of birds described by Hitchcock were all redescribed as those of reptiles by Lull in his studies. Tracks of birds have been reported from Kansas and from Mexico but they are doubtful specimens at the best.

One of the earlier tracks found in Europe was described as that of Archaeopteryx, but later investigation showed that it belonged to one of the smaller reptiles. At some future time we may expect to hear of the discovery of the track of Hesperornis regalis or some of the other well known water birds, but it is probable that both bird and animal foot prints will remain among the rare finds. It seems that our best examples of mammal tracks will be found in those of Canis and Homo, left in the cement of our modern sidewalks.

The chief interest of the fossil footprint lies in the fact that they make the animals live again in our imagination and give intimate records of their activities.

The finding of the tracks of animals long since extinct make a new and vital contact with these forms and adds materially to our interest, since they give us something that their fossil skeletons cannot tell.

NOTES ON THE HABITS OF RHINONCUS PYRRHOPUS BOH

W. V. Balduf, University of Illinois

By sweeping patches of smartweed between July and October, one is almost sure to get a small snout-beetle about 2.3 mm or .09 inch long. Its body is robust and clothed above with rather coarse brown pubescence, and beneath with white scales. On each side of the prothorax there is born an acute tubercle, and the wing covers are marked at the base on the median line with an elongate white or yellowish spot. This beetle is *Rhinoncus pyrrhopus* Boh. Two other species of *Rhinoncus* occur in America, which may be distinguished from *pyrrhopus* by the much larger size of *pericarpius* Gyll., and the absence of the lateral thoracic tubercles in *longulus* LeC. *R. pyrrhopus* is known to occur from New England and Ottawa, Canada, west to Colorado, and southward to Texas. Careful studies of the American species of *Rhinoncus* do not seem to have been made.

This snout beetle was found common on smartweed (*Polygonum*) at Urbana, Illinois, on July 18, 1924. Seven pairs were isolated in small vials and provided with fresh smartweed leaves for the sake of making observations on their seasonal development. These studies were supplemented with occasional field trips.

Mating usually begins about the first of July and was delayed last summer by the prolonged cool weather. These beetles were most energetic in copulation in mid-July, but continued with noticeable abatement at least until August 8, or for three weeks. However, as late as September 2 one male exhibited a notable tendency to mate. The males of this species spend considerable time perched upon the backs of the females, even when not in copulation.

The first eggs were found in the cages on July 20. They are at first lemon-yellow, but as the date of hatching approaches the color changes to a dirty orange. In shape they are oval, broadly and equally rounded at each end, and ½ mm long by 1/3 mm in largest diameter. The surface is finely roughened and light colored, sug-

gesting the exterior finish of a frosted light-globe, and sculptured with superficial hexagonal depressions which are limited by slightly elevated boundaries rounded above. The yolk showing through this covering is the source of the yellow color of the egg.

In the cages where only parts of smartweed leaves were available the eggs were sometimes dropped singly over the leaf surface, and at times in masses of two to four. A singular and rather habitual oviposition act is the deposition of one or more eggs with a mass of excreta. Whether the eggs are laid first, then covered with excreta, or both are deposited together is not known. The eggs thus covered entirely or in part were noticed to hatch in greater number than those completely exposed to the air. Not only does this device prevent too rapid evaporation of moisture from the eggs on hot dry days, but it seems to make relatively secure the position of the eggs near the larval food on a plant whose surface is glossy and bare. But even with the covering of excrement to hold them on, moderate jostling of the plant was seen to cause eggs to loosen and fall. Beetles exposed to a growing plant in a cage never oviposited on the leaves. The characteristic position of the eggs is between the leaf sheath and the main stem, the position under the sheath seeming to depend upon the distance the female can enter there. Therefore, if the eggs were loosened by contortion of the stem they probably most often lodge within the sheath. Some females caged with a bit of leaf and leaf petiole inserted their eggs under the end of the petiole where it rested on the bottom of the vial. This seems to suggest that the female backs up to a crevice as far as the opening permits and inserts her eggs. Such a process was observed to be rather prolonged in an instance in which the beetle maneuvered to aim her pygidium into a tight space between the cork stopper and the neck of the vial in which she was caged. No eggs were laid in this case.

Although two to four was the usual number of eggs observed to be laid daily, twelve were deposited in one instance. The last eggs were found on September twenty-third, making a known oviposition period of ap-

proximately eight weeks. Under indoor cage conditions the period of incubation was about eight days in midsummer.

The newly hatched larva is a fleshy grub, which when outstretched in crawling, is one mm. in length. It is light straw-colored to whitish, the head distinctly broader than the thorax, and each of the thirteen thoracic and abdominal segments has a lateral, broad, fleshy process on each side. Each process bears a flaxen colored hair. Similar hairs are scattered sparsely over the rest of the body. The larva in all stages lacks both the true thoracic and the false abdominal legs. The mature larva attains a length of about four mm. and in respects of shape, color and possession of hairs is similar to the newly hatched stage.

The first larvae were seen on July thirteenth. Hatching probably took place earlier in the field, for eggs were found in the cages soon after the beetles were caged. Upon hatching, the young larva crawls only a few centimeters or less to the node of the main stem just below the point where the eggs were usually deposited. A few tiny larvae in the cages were noted to contain green material in their alimentary tracts, indicating that leaf tissue is also taken as food when circumstances make this necessary. Larval development occurs for most part within the stem. The process of reaching the interior is a combination of negative reaction to light and positive response to gravity and pressure. The larvae kept under observation crawled downward to the point between the stem and the leaf sheath where the acute angle formed by these parts prohibited farther progress. At that spot the larva begins chewing its way into the stem, depending on the leverage it gains from bracing against the leaf sheath. Observations on a particular individual showed that by a continuous process of chewing for three hours and thirty-five minutes, this larva succeeded in boring its way just out of sight, leaving a ring of yellowish frass on the periphery of the hole.

Although legless, these tiny larvae are capable of locomotion on the smooth stem between the nodes. The above larva was placed on a leaf. It crawled downward,

successfully crossing the narrow leaf petiole, and moved down the main stem a distance of two inches. The two inch space was traversed in about nine minutes. This particular larva stayed on the shaded side of the stem, and crawled around to the other side when the stem was turned so the larva was exposed to direct light. When it had entered as far as possible into the shelter of the sheath it began penetrating the stem at once.

Studies on this specimen were continued on a growing smartweed plant in a cage. Fourteen days after entering the stem, it had grown to a length of three and a half mm. and had burrowed in the tissue of the stem to a point fifteen mm. above the place of entrance. Judging by the size of the tunnel the burrow was made when the larva was quite small. It stopped to eat out small reservoirs at two points along the way. A burrow was made downward also, but in no case were the burrows more than fifteen mm. from the entrance hole, and always entirely within the nodal area where the stem is fleshy and not so fibrous or tough as at the internodes. The cavity in which the larva was located after two weeks feeding was two mm. in diameter. Dissecting smartweed stems from the field showed that the usual abode of the larvae is in cavities made in the nodes. The size of these completed burrows is several times the volume of the larvae that made them. The larvae may also at times move from node to node by way of the natural central hollow of the stem. In one instance noted the body became necessarily much attenuated to make passage through this cavity.

Larvae were not reared to maturity, but one developed about three-fourths its full size in eighteen days, indicating that the larval stage lasts approximately three weeks in mid-summer. A very few larvae three to four mm. in length were found in outdoor plants as late as October eighth. Therefore, from the date of the first eggs on July twentieth, to the probable date of emergence of the adult in late August, may be a period of four or five weeks, allowing eight days for incubation, twenty-one for larval growth and the rest of the time for pupation.

Specimens of overwintered adults taken on July eighteenth were kept alive until October twelfth, when they were killed accidentally. During these twelve weeks they had subsisted entirely on a diet of smartweed leaves. In nautre the beetles are most commonly seen on the foliage of their food plants, where they probably usually feed. But in several instances subquadrate holes were seen gouged in the stem under the diverging leaf sheaths. In two such holes, which were almost the size of the adult beetle, several eggs were found. It does not seem probable that these holes are made for oviposition, as in the case of the plum curculio. Obviously they are made as a means of securing food and the eggs may have been dropped into the hole later accidentally.

The old beetles become somewhat rusty in appearance in late fall, and all are probably dead out of doors by early October. In contrast with the survivors of the old generation are the brighter colored adults of the new brood. The period of emergence of adults is from about the latter part of August to late fall, perhaps continuing near to November. Beetles were fairly common on October fourth at Urbana, on smartweed that was still green with succulent leaves, but were not available on plants bearing dry foliage and mature seeds. On October sixteenth and seventeenth the species was still abroad, but not plentiful, and difficult to detect because the smartweed seeds were swept up in the collecting net in quantities. Amid the seeds the snout beetle was well concealed, for the seeds and the beetles are about the same size and not well differentiated in color. They are discovered only by careful scrutiny of the seeds or by waiting patiently until they become active again after their death feint. The beetles collected on the above dates were kept alive until October twenty-ninth, when they died perhaps from the lack of proper hibernating conditions. Never was any tendency to mate observed among the new brood beetles; hence, there is without much doubt only one generation per year in this latitude. The winter is spent on the ground under the shelter of refuse near the plants on which the insect occurs when cold weather makes locomotion impossible. One beetle was found in

such a situation on April 13, 1925, when the smartweed was only two inches tall.

This beetle apparently does not use its wings for flight. Its distribution is dependent on its legs, which are used in two ways. First, it is capable of running rapidly over the leaf surfaces, and probably spreads by running from plant to plant. On the other hand, the beetle frequently makes its departure from the plant by a sudden jump. Jumping is effected by the enlarged hind femora. The employment of this means of locomotion seems not to serve for ordinary passage over the plant, but rather as a device for getting off the leaf. The distance traveled in this way is only a few inches, which is sufficient to clear the leaf, and gravity completes the act of escape. When the beetle strikes a resting place it "plays possum" for a short time. If left undisturbed momentarily, it nimbly scrambles to its feet and soon renews its activities on the food and host plant.

OPPORTUNITIES FOR FIELD STUDY IN THE CHICAGO AREA

HILARY S. JURICA, ST. PROCOPIUS COLLEGE, LISLE, ILL.

If one chances to glance over a map of the Chicago region, especially if it be one prepared by the Geographic Society of Chicago for their Bulletins Nos. 1, 2 and 5, and observes the bodies of land and water, together with the net work of railroads and electric lines reaching almost any part, one cannot help but be impressed with the thought that this must be a region of great opportunities for the naturalist, no matter what particular line of natural history he may be interested in; a veritable paradise for the students of physiography, geology, botany and zoology. Our interest is intensely aroused, when, by perusing these bulletins, we note that the region has already been well worked out, that is, the different geological formations, plant societies and animal communities indicated. And this more so when we consider that the universities of this area conduct well organized classes thru these regions, one especially along the graduate level.

But stop for a moment in your enthusiasm! Look at the date of the said publications—two of them just about twenty-five years old and the other only twelve. Select one of these animal communities or plant associations along any of the commutating lines, be it west, north or south. The fare is cheap and the rail service excellent. What more does one need for an incentive to read or listen to the story that this particular animal community or plant association has to say? But how sad is the disappointment when, map in hand, we watch the stations as we pass along to reach our destination! No longer is region so and so known as a virgin prairie, for, instead of a prairie association, we meet with an association of bungalows, cottages and stores. The oak and hickory forest is giving way to streets and avenues. Even the marsh is being filled up, and where but six years ago cattails and rushes abounded, a sign takes their place offering homesites in beautiful Stony Island Gardens. The Lake Shore is no better off. For, when our class at-

tempted to make a study of the corroding shore at Glencoe, Dr. Wells found it actually impossible to let the guard understand the harmlessness of our intentions. And only after much difficulty we succeeded in reaching the lake, by winding our way down an irregular ravine, only again to be informed by another guard that our presence was not wanted there, even if we were bent on nothing else but to study and perhaps to catch a few tiger beetles.

The steam shovel of the Consumers Company has almost completely leveled the region of Dr. Cowles classic study of the dunes and is threatening to remove still more.

With the lake shore for quite a distance in the hands of a railroad company and other places controlled by private individuals, it is beginning to seem to us as if we had no Lake Michigan, at least as far as certain sections are concerned. With the passing of the plains and subdividing or cutting down of the forests, filling or draining the marshes, we can readily imagine what the future of field studies may be in the Chicago area. To be sure it is rather pleasing to hear that the city is spreading out into the country, and that it is the younger generation that is leaving the congested region of the overcrowded city to build homes in places where more comfort, health and sanitation are possible.

But is every marsh, plain, forest, and water side to be sacrificed to the wishes of the real estate investor or home seeker? Thank God that such is not the case, for some public spirited citizens have held certain forested regions, refusing to sell or subdivide. Others again have seen gain in holding such tracts for picnic or outing purposes. And the very danger of losing every inch of forested or open spaces has prompted far-seeing citizens to cause the passage of a state law, empowering counties to form forest preserve districts. Scenting the danger they happen to be in, some of the naturalists of Cook County took the lead and aroused sufficient public sentiment, not only to form a forest preserve district, but to buy up almost everything that was still available, or not spoiled by real estate agents. The forested holdings of

public spirited citizens and the former picnic or outing groves were the first to be purchased and formed not only into a forest preserve, but into a sanctuary as well, where birds, flowers and trees would thrive unmolested. In short, they were converted into regions where the fauna and flora could be preserved, so that the natural beauty of our vicinity for the future would not be a mere matter of history, but would be available for study, even for generations to come.

The purchasing is continuing as fast as funds are available, or as sometimes is necessary, as fast as condemnation suits can proceed—so much so, that it has spread its contagion into the neighboring county of DuPage. To date, Cook County has some 27,000 acres scattered about, but a great deal of it is in an almost continuous stretch along the Des Plaines River. DuPage County has about ten small forest preserves. Although there is no forest preserve in Will County as yet, nevertheless the eight hundred acres of the Joliet park district amount to much the same thing.

That the forest preserve law was no mistake is evident from the fact that over six million people made use of the forest preserves during the year 1922 in Cook County alone. The people making these visits entered either as members of private camping or outing parties, members of some school class doing field work, or simply partaking in an organized outing, directed by some church, fraternal, or benevolent organization. No matter what the plea or pretext for such a visit was, it certainly did not fail to educate in a lesser or greater degree, depending on the nature of their organization. But even if we view the least sought by anyone, it is certainly worth while, for it surely does instill an appreciation of nature, which cannot but have its cheerful influence in leading one to respect the natural and acquired rights of others, which means so much for good citizenship.

The active interest taken by the varied groups of nature lovers, both on the laymen and the professional level, has prompted some to suggest work beyond a mere conservation of what can be preserved, something along the constructive lines. And while there is talk of forming

an arboretum upon the beautiful topography of the historic Palos Park region, and some attempt has been made in the Joliet park district in the way of an arboretum, a public spirited citizen of DuPage County, a lover of trees, set aside a tract of a few hundred acres about his residence in Lisle. This he endowed: "Creating a foundation to be known as the Morton Arboretum, for practical, scientific research work in horticulture and agriculture, particularly in the growth and culture of trees, shrubs, and vines by means of a great outdoor museum arranged for convenient study of every species, variety, and hybrid of the wood plants of the world, able to support the climate of Illinois, such a museum to be equipped with an herbarium, a reference library, and laboratories, both for the study of trees and other plants, with reference to their characters, relationships, economic value, geographic distribution and their improvement by selection and hybridization; and for the publication of the results obtained in these laboratories by the officials and students of the arboretum in order to increase the general knowledge and love of trees and shrubs, and bring about an increase and improvement in their growth and culture." From the words used in creating the institution known as the Morton Arboretum, as well as from the policy pursued, it is evident that Mr. Joy Morton's idea was not simply to add something to what we already possess for either study or enjoyment, but to supply what was wanting in our area, in fact in our state and even in neighboring states, a real need.

In arranging the general plan of the arboretum, care was taken and emphasis laid upon its usefulness to teach in a manifold manner. For the sake of the taxonomist, trees and shrubs are arranged according to their botanical classifications, so that related forms may be easily compared. The plant geographer will be pleased to know that other groups have been arranged to illustrate such geographical regions as Japan, Northern China, Amurland, Siberia, The Balkans, Caucasus, the Pyrennes, etc., as far as their hardiness will permit. Considerations have also been made for the ecologist, in arranging certain groups to illustrate the zones of plant life so commonly found in many countries, but at great distances apart.

To be sure they will be artificial, but their educational value will not be diminished.

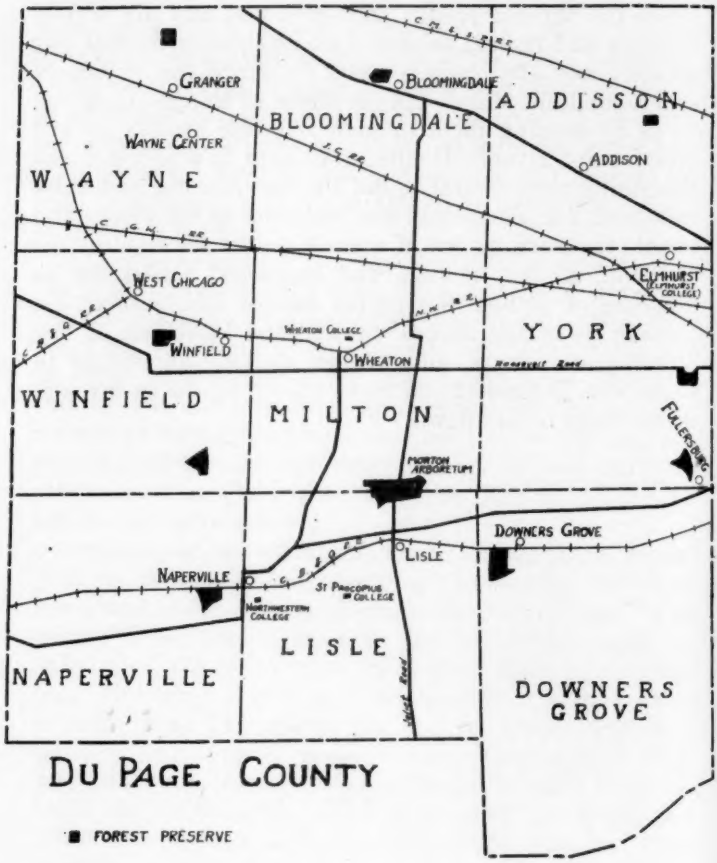
The lovers of formal gardens, especially in the line of roses, will find plots entirely to their liking. Even the economic forester has not been overlooked, for test plots of forest and lumbering trees have been set out. A working library has been started and is housed for the present in the library section of Joy Morton's residence.

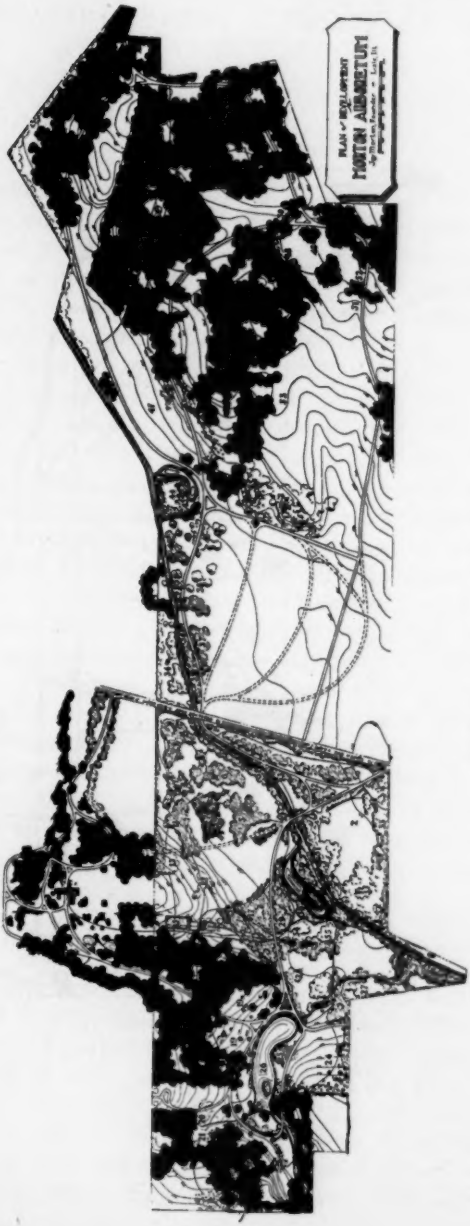
Provision has been made to check possible invasion of insect pests by inviting the feathered tribe to nest and home unmolested throughout the arboretum, having at their disposal bird houses and an unusual amount of food. In short, nothing is spared to make the region attractive for them.

It is true some may say this reads like a dream; it is but a start and it will take years before it develops. That is true, but Arnold's Arboretum is only about fifty years old. And you all will concede that it is not too late to start development along such broad lines. Its usefulness has already been appreciated by the visiting classes of various educational institutions on the university, college and high school levels. It has attracted attention of professional men, the Prairie Club and nature lovers in general.

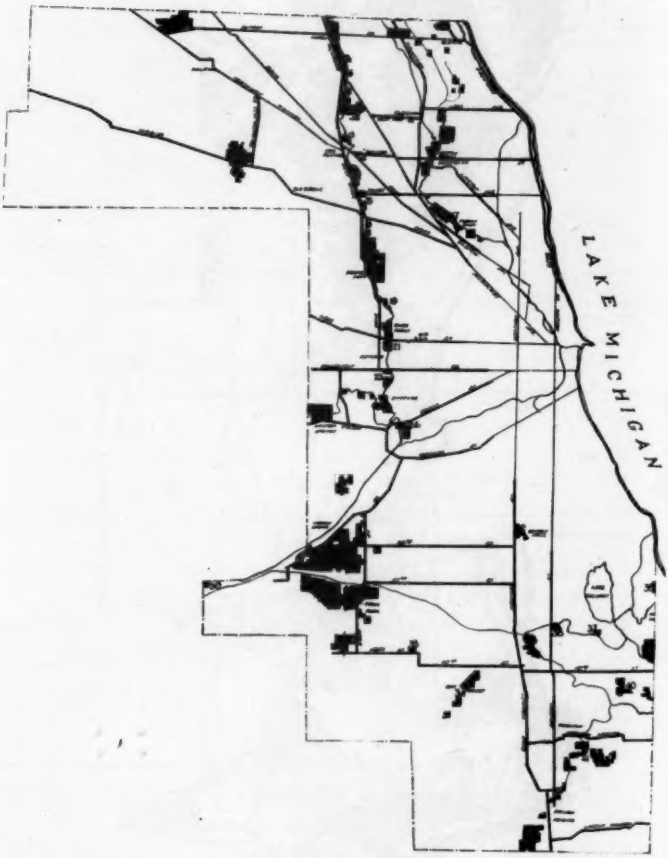
Summing up the situation in our Chicago Area, we are glad to announce that this great awakening has been made and that progress is along the correct lines. Our parks, forest preserves, and the arboretum seem to satisfy, or will do so when the present plans are carried out. But what a pity to think that practically nothing is being done to conserve the natural beauty and loveliness of our aquatic bodies! Lake shores, both large and small, are disappearing in many parts. Bogs are becoming inaccessible, and our streams are badly polluted with sewage and industrial waste from the cities and larger towns throughout this area. Hence it is with a plea that I conclude this message. Extend the forest preserve system not only in our vicinity, but throughout the state, so that future generations will not be obliged to send forth lamentations such as we hear from the corn desert area of the state university zone, where an at-

tempt is being made to save the Brown Field Woods, a small but the only piece of forest available for the nine thousand students of the State University. And let us determine that upon our return to our institutions and communities, we will strive to create a sentiment of appreciation of our duties as citizens, to conserve and preserve the natural beauty and loveliness and life of our streams and rivers; to create an awakening so that our citizens and city fathers may recognize the rights of others, and not simply rid ourselves of things obnoxious to us by sending them to some one else by way of our streams and rivers. Health, to be sure, is a problem and something very desirable, but the question can and must be solved, for science can and will come to the rescue and enable the working out of a satisfactory solution of this problem, so that sewage and industrial waste can be disposed of without destroying aquatic life, without depriving us of the natural beauty and loveliness of our streams and rivers, and without causing annoyance to those who live about and make use of the lands through which these bodies flow.


GRANGER
BLOOMINGDALE
ADDISON
BLOOMINGDALE
WAYNE CENTER
ADDISON
WAYNE
WEST CHICAGO
ELMHURST
(ELMHURST COLLEGE)
WHEATON COLLEGE
YORK
WINFIELD
WHEATON
WINFIELD
MILTON
FULLERSBURG
MORTON ARBORETUM
DOWNERS GROVE
LISLE
NAPERVILLE
ST PROCOPIUS COLLEGE
NORTHWESTERN COLLEGE
LISLE
NAPERVILLE
DOWNERS GROVE
DU PAGE COUNTY
FOREST PRESERVE



Black area denotes natural forest.



Cook County Forest Preserves.

PAST AND PRESENT INTEREST IN ILLINOIS TREES

R. B. Miller, Natural History Survey, Urbana

INTRODUCTION

In connection with the work of the State Natural History Survey of making an authentic list of native Illinois trees and writing some notes upon them, we had occasion to look up pressed specimens of trees in the herbaria of the Field Museum of Natural History, Chicago, and of the University of Illinois. We found this examination of considerable interest, not simply because we were able to see specimens which had actually been collected, but for the contact it afforded with the work of early botanists and scientific men of this state and others.

So impressed were we with the care and thoroughness with which these collectors did their work for the mere love of it that it suggested the subject of this paper, "Past and Present Interest in Illinois Trees". Since the subject matter is perhaps not suited for presentation in a state bulletin, we thought it might be of interest to the members of the State Academy of Science and others. This chronological outline of attempts to classify plants and especially trees is by no means complete but merely suggestive. It would be an interesting and worthwhile piece of work for someone to present a brief biographical sketch of each collector. This is a task which might well be considered by present day botanists who owe much to the painstaking care of these early investigators.

A. *Past Interest in Trees.*

As early as 1794 Andre Michaux, a distinguished botanist of France (Thwaites, 1748-1846), visited Illinois in search of plants which were to be sent home to enrich the gardens and pleasure grounds of his own beautiful country. The elder Michaux made his travels into Kentucky in 1793-1796, and his son, Francois Andre Michaux, traversed the wilderness west of the Alleghenies in 1802. The journal of the elder Michaux re-

cords "the impressions of a man of unusual intelligence, who had learned by long practice to use his eyes to good advantage and to write down only what he saw." In 1803 there was published in Paris his "Flora-Borealis-Americana" written in Latin by Richard from the plants which Michaux had collected in America. A number of plants are set down as having been found in "regione Illinoensis".

Some of the notes found in Andre Michaux' journal about the medicinal and other values of trees and shrubs are of interest, from which we have selected only a few:—

Liquidambar. (now the red gum.) "A Frenchman who traded among the Cheroquis savages cured himself of the itch by drinking for ten days a decoction of chips of that tree which he called copalm and which is the true Liquidambar."

Celtis occidentalis—Hackberry.

"The 7th of November confirmed my opinion that the second bark of Celtis occidentalis (called in the Illinois country Bois connu and toward New Orleans Bois inconnu) is an excellent remedy for curing jaundice; a handful of the roots or leaves of Smilax sarsaparilla is added to it; it is used for about eight days as a decoction."

Padus virginiana (Prunus virginiana)

"In making wheels for vehicles the workmen use the wood of Padus virginiana for the felloes, elm for the naves and white oak for the spokes."

Cuercus—Oak.

"Having nothing to do on January 2nd. I made ink with gall nuts which I gathered on the oaks in the vicinity of the spot where we camped. It was made in less than five minutes and will serve me as a sample."

Benzoin Benzoin—Spice Bush.

"I had supped the previous evening (Wed. Feb. 10, 1796) on tea made from the bush called Spice Wood. A handful of young twigs or branches is set to boil and after it had boiled at least a quarter of an hour sugar

is added and it is drunk like real tea. This beverage restores strength and it had that effect for I was very tired when I arrived. This shrub is the Laurus bensoin (Linn.). The Illinois French call it Poivrier and the hunters season their meat with pieces of its wood."

Nuttall (1821) has many references to trees found in his journey down the Ohio and up the Mississippi river to the "Arkansa Territory". We can only quote one of these, although they add to our knowledge quaint uses of some of our trees:

"*Gymnocladus dioicus—Kentucky Coffee Tree.*

Among the trees we still continued to observe the coffee bean (Gymnocladus canadensis) now loaded with legumes, the seeds of which when parched, are agreeable to eat but produce a substitute for coffee greatly inferior to Cichorium."

J. A. Lapham, of Milwaukee, Wisconsin, made journeys into this state as early as 1836 and published a catalogue of the plants of Illinois about twenty years later (Lapham, 1856). Dr. George Engelmann, of St. Louis, after examining collections made by Mr. Robert Kennicott, Mr. Emil Claussen and others exhibited at the State Fair in Chicago in 1835, said: "It seems that there are 70 species in Illinois that attain the height and dignity of forest trees, including 12 or 13 species of oak. The rich bottomlands along the margins of the Mississippi, the Ohio and the Wabash afford specimens of the noblest and most gigantic trees of the great valley of the west." Mr. M. S. Bebb added several species to Lapham's list from northern Illinois.

The idea of making a reliable list of trees with their local occurrences in the state was suggested by Frederick Brendel (1858). He urged that the members of the Natural History Society and others should unite in an effort "to ascertain the northern and southern limits of trees and that a paper on the subject should be published in the Transactions of the State Agricultural Society." In accordance with this suggestion men from different parts of the state did report upon the trees found in their county, and we find that Samuel Bartley,

of Murphysboro, and Mr. C. Thomas of Marion, made such observations in Jackson and Williamson counties. With the idea of assisting in this work Dr. George Vasey, of Ringwood, published an article in Emery's Journal of Agriculture and Prairie Farmer in 1858, giving explicit directions for the pressing and mounting of plants.

Frederick Brendel (1858) read a paper before the Natural History Society at Bloomington on "Forests and Forest Trees", in which he listed the trees found in Illinois and compared the number with that found in Europe. After enumerating the six conifers which are found today in the state he says: "The bulk of our woods is composed of more than 60 species of trees with deciduous leaves, amongst which we have 40 of large size . The constituents of the copses are about 40 different shrubs. Compared with European woodlands this is a large proportion. In all Europe north of the Alps we count scarcely more than 30 different species of large forest trees."

Mr. Brendel (1858) also published an article on "The Trees and Shrubs of Illinois" and followed this up with two others, both very well illustrated, the first on the oaks in which their specific gravities were given, and the second on the beech, the elms, the hackberry and the mulberry. Both combined give an accurate and well written account of the trees of that period, and the same descriptions could well stand today.

We find also that the early geologists under the head of agriculture reported upon timber in some of the counties in addition to soils, building stone, limestone and clays. Dr. Worthen (1866), the first Director of Geology, made some very detailed observations about trees in their relation to geology and soils as observed in St. Clair, Madison, Hancock, Hardin, Pulaski, Massac and Pope counties.

Harry N. Patterson in 1874 published a list of ferns and flowering plants near Oquawha and (1876) published a catalogue of the plants of Illinois. In this 709 species were enumerated, of which 654 were found growing within three miles of Oquawha, Henderson County.

Burrill and Flagg (1878) made a list of the plants of Illinois and among the notes are many concerning trees. One interesting fact mentioned is the occurrence of American chestnut (Castanea dentata) over a tract of some 80 acres at Olmstead, Pulaski County, classed as native. It was from this grove that Mr. B. T. Gault, of Glen Ellyn, secured in 1900 a photograph of a tree about four and a half feet in diameter and prepared a wood specimen from one of its branches about three inches and a half in diameter. This specimen, along with others, was presented by Mr. Gault to the University of Illinois. This was the same place also where Chestnut was observed by Mr. William Trelease (1917) and where specimens were collected by the Forestry Survey party in the summer of 1924. Mr. Flagg, who assisted Prof. Burrill, said concerning his collaboration that "he was no botanist but was simply working from a practical standpoint and endeavoring to show the possibilities of plant culture, agricultural and horticultural, in Illinois."

The following is a list of those whose names have appeared most often on the herbarium specimens which we have examined:

M. S. Bebb, Fountaindale, Winnebago County.

Dr. George Vasey, Ringwood, McHenry County.

Rev. E. J. Hill, Englewood, Cook County.

Dr. Frederick Brendel, Peoria, Peoria County.

Elihu Hall, Athens, Menard County.

Dr. Jacob Schneck, Mt. Carmel, Wabash County.

Robert Ridgway, Olney, Richland County.

E. H. Hill, Chicago Heights, Cook County.

T. J. Burrill, Champaign and Bureau counties, Urbana, Illinois.

Harry N. Patterson, Oquawha, Henderson County.

W. E. Andrews, Carlinville and Taylorville, Macoupin and Christian counties.

Frank C. Gates, Carthage, Hancock County and Urbana.

Virginius H. Chase, Wady Petra, Peoria County.

Agnes Chase, Glenwood, Cook County (and Peoria County).

George P. Clinton, Champaign County, Urbana.

H. Welch, Mascoutah, St. Clair County.

Rev. John Davis, Hannibal, Mo. (who collected in Pike County, Illinois).

Dr. J. T. Stewart, Peoria and Normal.

I. S. Raymond, Villa Ridge.

C. F. Millspaugh, Chicago.

L. M. Umbach, Naperville, Northwestern College.

B. Present Interest in Trees.

Present interest in the subject of trees is by no means wanting among systematic botanists, ecologists and the general public. That people want information about trees in Illinois is indicated by the numerous requests which have been received for information on the academic as well as the economic side. The interest in trees from the standpoint of the plant association has received stimulation by the work of such men as Pepoon, Ridgway, Cowles, Fuller, Waterman, and McDougall in Jo Daviess, Richland, Cook, LaSalle, Lake, Vermillion, and Champaign counties and the many botanical excursions into southern Illinois led by such enthusiasts as Dr. Cowles of Chicago, Miss Steagall of Carbondale, and Prof. Bonnell of Harrisburg. Many papers on trees have been published within the last five years in the Proceedings of this Academy. Just at present, besides the publication planned by the Natural History Survey, we know of at least two other books on trees which will be published within the next few years, besides two county reports on ligneous plants and a pamphlet on the trees of the Chicago region. All of this indicates that within the next few years the subject of trees in this state will be adequately covered, and not only the botanists of other states can find the information for which they may seek but those in our own state interested from the standpoint of nature study alone will find simple tree descriptions suited to their purpose.

The foresters of the Natural History Survey have uncovered many interesting facts about the life and growth of trees since the summer of 1921 which are to be presented soon in the form of bulletins. Some preliminary facts may be of interest.

According to a careful inventory there are about 90 native trees in this state. This number has been arrived at by omitting doubtful varieties, those which may not reach tree size and those which are doubtful because of changes in nomenclature since collections were first made in the state. Since as many as four or five different names have been given to trees which were collected in 1875 and minor differences have added new varieties, the difficulty of making a correct list can be appreciated. Some of these points have not even been settled among the botanists themselves.

Out of this total of 90, 84 are hardwoods and 6 are softwoods or conifers. There have been actually collected 18 oaks; 7 white, 9 black and 2 willow oaks. There are 7 hickories, 6 ashes, 4 each of birch, maple and elm, 3 locusts and 2 hackberries. Seventy-three species native or once native have been reported from Richland County alone by Robert Ridgway, of Olney, Illinois, but he has considered refinements in the making of varieties which the ordinary person would find troublesome, so that for practical purposes the number may be somewhat less than this. Miss Alice Kibbe reports 53 species from Hancock County and Prof. W. B. McDougall lists 30 species as native to the University Woods, Urbana, after omitting all of the Crataegi except Crus-galli and mollis.

The largest living tree measured in the state was a burr oak in the Brownfield woods near Urbana, which was 15¾ feet in circumference at a point 4½ feet above the ground and 104 feet in height. A close second to this was another burr oak in Union County which was slightly over 15 feet in circumference at the same point, which made very close to 5,000 feet of lumber and was 220 years old. The oldest tree stump counted in the state had 330 rings, a tupelo gum in the Cache River bottoms. Among the trees added to the list before known for the state by looking over herbaria and by collections actually made in the field, are the yellow birch, the water hickory and the willow oak.

As to growth, the most rapidly growing species in plantation was catalpa in Starke County, 13 years old, which had averaged 160 cubic feet per acre per annum; the fastest growing not in plantations was the cottonwood

near a levee and a mixture of soft maple, sycamore and ash near a drained lake at Havana which has produced 140 cubic feet each or about a cord and a half of wood per acre per annum. The slowest growth recorded, unless it be for post oak on post oak flats, was for a growth of white and other oaks on a hillside in Union County which had never been thinned except by natural processes and which had added 16 cubic feet per acre per annum.

Thus it seems possible for the forester by actual measurements and computation to correlate cubic feet or even pounds of wood per acre with different soil types and thus tell with reasonable certainty what wood crops are most liable to pay a profit on the different classes of soil just as the farmer can estimate his crops in tons or bushels per acre. Thus facts which are of interest to the general public such as the number of species, size, and age of trees in the state can be supplemented by facts which are of far reaching significance to the timber grower and those interested in land utilization—answering the questions of how much timber can I expect in a certain number of years and will it pay to grow it? And after all, these are the questions which are worth while considering, and upon the successful and accurate answers to which depend whether or not the private owner, under equitable systems of taxation and reasonable safety from fire and other hazards, can afford to enter into timber growing as a business.

TREES OF THE LOWER WABASH VALLEY OF ILLINOIS AND INDIANA

According to Robert Ridgway (1872, '82, '83, '94), who has written several articles on the trees of this region, it was remarkable both for the large number of species represented and the magnificent proportions of individual trees. He says that in one square mile of woods there was a grand total of more than 70 trees, not including several of the larger shrubs. Many of them were described and measured by Mr. Ridgway for Professor Sargent's report upon the forest trees of North America for the tenth census, and these notes have been published in a series of articles. He was assisted in

making the measurements with the tape on felled trees and with the hypsometer on standing trees by Dr. Jacob Schneck of Posey County, Indiana. The number of indigenous trees in the Lower Wabash Valley from the mouth of the White River southward was around 107, while a number of shrubs such as witch hazel, spice bush, and sumach reached the height of 30 feet. The largest trees were the sycamore, tulip poplar, pecan and sweet gum, all of them being over 175 feet tall and one tulip even reaching 190 feet. Mr. Ridgway in 1875 measured a sycamore on the Indiana side of the White River within three miles of Mt. Carmel, Illinois, which had a height of 160 feet, a circumference above the swell of the base of 38 feet and a crown spread of 134 feet. This was undoubtedly the largest tree east of the Rocky Mountains.

BIBLIOGRAPHY ON TREES OF THE LOWER WABASH VALLEY.

RIDGWAY, ROBERT.
1872. Notes on the Vegetation of the Lower Wabash Valley American Naturalist, Vol. 6, 658-665; 724-732.

RIDGWAY, ROBERT.
1882. Notes on the Native Trees of the Lower Wabash and White River valleys in Illinois and Indiana. Proc. U. S. National Museum, Vol. V, pp. 49-88.

RIDGWAY, ROBERT.
1883. Additions and corrections to the list of Native trees of the Lower Wabash Valley. Bot. Gaz. VIII. No. 12, pp. 345-352.

RIDGWAY, ROBERT.
1894. Additional notes on the Native Trees of the Lower Wabash Valley (with plates X-XV). Proceedings of the U. S. National Museum, Vol. 17, pp. 409-421.

BIBLIOGRAPHY

THWAITES, RUEBEN GOLD.
1748-1846. Early Western Travels. Edited with Notes, Introductions, Index etc. Volume III, pp. 11-104.
Cleveland, Ohio, the Arthur H. Clark Co., 1904.

NUTTALL, THOMAS, F. L. S.
1821. Journal of Travels into the Arkansas Territory during the year of 1819. Printed and published by Thos. Palmer, 1821, Philadelphia, Pa.

LAPHAM, J. A.
1856. Catalogue of the Plants of the State of Illinois. Trans. Ill. State Agricultural Society, Vol. 2, page 492—also continued in Vol. for 1857.

BRENDEL, FREDERICK.
1858. Trans. Ill. State Agr. Society, Vol. 4, page 436.

BRENDEL, FREDERICK.

1858. The Trees and Shrubs in Illinois. Trans. Ill. State Agr. Society, Vol. 3, page 588.

WORTHEN, Dr. A. H.

1866. Geology of Illinois, Volume 1, A. H. Worthen, Director, 1866.

PATTERSON, HARRY N.

1876. Catalogue of the Phanerogamous and Vascular Cryptogamous Plants of Illinois, Native and Introduced, Oquawka, Ill. Spectator Print, 1876.

FLAGG, W. C. AND BURRILL, T. J.

1878. Plants of Illinois, Introduced and Cultivated, 9th. report Ill. Industrial University, page 278. Sept. 30, 1878.

BRENDEL, FREDERICK.

1887. Flora Peoriana, The Vegetation in the Climate of Middle Illinois. J. W. Franks & Sons, Printers and Binders, Peoria, Illinois, 1887, pages 30-33.

TRELEASE, WILLIAM. .

1917. The Chestnut in Illinois. Trans. Ill. State Acad. of Science, Vol. X, 1917, page 143.

THREE ALFALFA DISEASES NEW TO ILLINOIS

L. R. Tehon, Natural History Survey, Urbana

The belief has been prevalent that alfalfa, in Illinois, suffers from the attack of but one serious leaf disease, the leaf-spot caused by *Pseudopeziza medicaginis* (Lib.) Sacc. The plant disease survey of our state, which has been under way for four years, reveals that while this is the most important disease there are at least three others of considerable significance.

MOLD-SPOT

The most common and most destructive of the three is the mold-spot, which is caused by a fungus known as *Macrosporium medicaginis* Cugini. It appears first as a small, yellow, discolored spot, which rapidly enlarges and becomes dead and brown. The infection may begin at any place on the leaf, but usually starts at the edge. Diseased spots enlarge rapidly, and those near each other may grow together, causing the destruction of a large part of the leaf. As they grow old they become wrinkled and almost black and the fungus grows out upon the surface so that its threads and spores give the spot a molded, sooty aspect.

No account of this disease has ever been published in America, although it is known in Europe. It was first found in Illinois July 14, 1922, in Shelby County. Another instance of the disease was found July 16 of the following year in Bond County. In 1924 many alfalfa fields were seen in which the disease was abundant. It is evident that the mold-spot is prevalent throughout the northern two thirds of the state, its seriousness becoming greater northward.

Like other alfalfa leaf-diseases, this one does its chief damage by destroying the leaflets and reducing the harvestable crop. The attack is general in infected fields, and the damage done is generally in proportion to the number of diseased leaflets. During the summer of 1924 the mold-spot was found on 20 per cent of the leaves on the plants examined in diseased fields.

BROWN LEAF-SPOT

The brown leaf-spot is known as a serious disease in many states, but has been found only recently in Illinois. It is caused by the attack of a fungus known as *Pleosphaerulina brisosiana* Poll. The spots are round or oval. They vary from less than the size of a pin-head to nearly a quarter of an inch across, and may be either at the edge or on the interior of the leaf blade. At the margin is a black ring which definitely marks the limits of the spot. The central part is dead, and varies from light tan to very dark brown. The number of spots on a leaflet is often large. The injury done to the leaf not only reduces its food value, but often results in a premature and severe leaf-fall, thus reducing the harvested crop.

The brown leaf-spot was first found in Illinois during 1923. Two diseased fields were seen, one in Macon, the other in Bond County. During the summer of 1924 it was found in many fields, so distributed as to make it certain that the disease is widespread within the state. Diseased fields were seen in the extreme south in Alexander County, and in three counties along the northern border. Other diseased fields seen in seven widely separated counties indicate its prevalence in the interior of the state.

In diseased fields the infection is usually quite general, practically all plants being infected. The amount of disease varies somewhat within the fields, according to moisture conditions influenced by soil and air. During the summer of 1924 infection was present on from 5 to 100 per cent of the leaves on the plants examined in diseased fields. The average of infected leaves in all the diseased fields reached 40 per cent.

DOWNY MILDEW

Previous to the summer of 1924, the downy mildew of alfalfa, caused by the fungus *Peronospora trifoliorum* DeBary, had never been known to occur in Illinois. During that season, however, it appeared generally and in considerable abundance throughout the extreme north of the state, and in the Illinois valley as far south as Mason County.

The character of the disease is such that it cannot be pictured easily. Infected leaves assume a yellow-gray, or slightly purple, water-soaked appearance. Diseased parts of the leaves are relatively extensive, and on their under sides one may find a coat of downy, violet fuzz. Infected leaves are not conspicuous; hence the disease may be prevalent in considerable quantities and yet escape notice. In 1924 the plants examined in diseased fields had an average of over 1 per cent of their leaves diseased. The extensive character of diseased spots, however, makes this disease more serious than the amount of infection indicates.

The value of the alfalfa crop is great. Because it is a legume, it fills a need in our system of rotation not readily satisfied by any other crop. The total acreage of the state amounted to 77,000 acres in 1924, and the average yield per acre reached 2.85 tons, giving a total yield for the state of 504,000 tons worth in the neighborhood of $7,812,000. Diseases tending to reduce either harvestable crop or the food value of the crop when it is harvested are not matters of light concern.

While there is definite need for experiment leading toward a satisfactory means of preventing these diseases, it appears probable that cutting the crop as soon as is safe after the diseases become prevalent will serve to keep them reasonably under control.

THE FOSSIL FLORA OF NORTHERN ILLINOIS

A. C. Noe, The University of Chicago, and the Illinois State Geological Survey

During Pennsylvanian times a large swamp stretched itself over most of Illinois, parts of Western Indiana, and Kentucky. An enormous accummulation of vegatable matter occurred there, developing in time an important coal field from which we now derive the benefit. The northern edge of this coal field runs a short distance north of the Illinois River, beginning in the east near the origin of that river where the Kankakee and Des Plaines rivers combine and running west in a straight line from the bend of the Illinois to the Mississippi. Near the northeast corner of the Illinois coal field lies a small mine near Braidwood from which large quantities of excellent plant impressions were collected out of the shales which overlie the coal. Another famous collecting place is the banks of the Mazon Creek near Morris, in Grundy County.

If we try to reconstruct a picture of the vegetation when the coal was laid down, our eyes see a tropical or sub-tropical swamp vegetation which contains gigantic club mosses and horse tails, big tree ferns, and climbing ferns, all small and large types of water plants, big gymnosperms, and, very likely, some angiosperms. In analyzing this picture we find something like two hundred or three hundred types of plants belonging to the great genera of Lepidodendron, Sigilleria, Calamites, Cordaites, Sphenoplyllum, and a host of Filicales and Cycodofidicales. The Lepidodendron tree, the most stately representive of that flora, reached the height of one hundred feet and had a bark which was covered with rhomboid leaf cushions. Related to it was the Sigilleria, whose leaf cushions were circular or hexagonal instead of rhomboid. The roots of both big groups were long, stretched, snake-like organs creeping in the swamp. We even know the anatomy of these plants, because the coal balls which I discussed at a previous meeting[1] produce beautiful microscopic sections of the tissues and woods

1) See A. C. Noe, Transactions Illinois State Academy of Science, Vol. 17 pp. 179, 180.

from fossil plants. The strange thing which we observe in looking at the wood of these trees is that they have no annual rings. Perhaps the climate of that time was even throughout the year with no seasonal differences. The reproduction of these plants occurs through spores which were produced in cones of the size of a pine cone.

The group of Calamites represents gigantic horse tails twenty to thirty feet high and from one to two feet in diameter, producing strong woody stems which bore peculiar longitudinal furrows on the outside. Here the reproduction took place by spore-bearing cones.

The fourth great tree group of that time was formed by the Cordaites, which had slender stems as high as a hundred feet and bore tufts of long gigantic needle-like leaves. These gymnosperms were of an extinct type, but somewhat related to our conifers.

A little smaller than the previously mentioned group are the tree ferns, but here we run into a peculiar difficulty. Apparently there were true ferns and fern-like gymnosperms at that time. These plants bore leaves of ferns and seeds of gymnosperms. Judging from the thousands of impressions which paleobotanists have gathered of fossil ferns and fern-like plants, there must have been a great variety of them.

Finally, we may mention a small group of fern-like water plants—the Sphenophyllales. They had wedge-shaped leaves attached to floating stems whose ends bore cones filled with spores.

The flora which I have just sketched is taken from the roof of coal No. 2, but corresponds to a European flora, like the Stephanian of France or the Ottweiler series of the Saar Basin, which are much higher in geologic position. It seems to us as if the fossil plants of the so-called No. 2 coal would either force us to give another number to the coal or to disbelieve the generally accepted theory of a uniform flora in carboniferous times which extended all over the earth from the Artics to the Antarctics and whose contemporary horizons must have shown almost identical composition.

SOME INTERESTING SOUTHERN ILLINOIS PLANTS

G. H. French, Herrin, Illinois

In order to have a proper understanding of the flora of this part of the state we need to know something of the geology of the region. A range of hills crosses the state from west to east, and at the point where the Illinois Central Railroad passes through the range, as well as farther westward, we have several geological formations represented. The best outcrops of these as seen at Grand Tower are the Onondaga, Hamilton, and Oriskany. South of these are the Burlington, Keokuk and Chester, while toward the north are the Subcarboniferous and Carboniferous as is shown by two thin layers of coal out-crop south of Makanda. But it is not the geological aspect of this one-time barrier to an inland sea in which we are interested so much as the setting it makes for a flora.

The range of hills gives us an overlapping of the northern and southern floras, as well as of the insect faunas. Speaking of the trees, the small Shellbark Hickory (Hickoria alba), which occurs in the eastern states as far north as central New York, is found on the uplands here. We also have at least four other hickories (H. amara, H. porcina, H. tomentosa and H. sulcata of Torret), and in addition the pecan grows wild in some places. The oaks are just as prolific as the hickories in forms, as anyone who attempts to classify them will find; and he will find also that he must be good at identifying the parentage of hybrids. Occasionally a large beech tree is to be found on the uplands of the ridge, reminding one of the eastern states.

Maples are represented in four fairly well marked forms; Sugar Maple, Soft Maple, Red Maple and Drummond's Maple. I hardly want to call the last a variety of Red Maple as the habits of growth of the trees are different and the fruits are different.

Besides the two ordinary elms we have the Winged and Semi-winged (Ulmus alata and U. plumosa). The first is often a small bush.

One of the most curious of the shrubs is the Hercules Club (Aralia spinosa). As seen in winter it is 8 or 9 feet

high covered with stout spines and without branches. In summer it is like an umbrella, with bipinnate or tripinnate leaves and an upright panicle of small flowers or dark colored berries.

In the cane bottoms, south of the ridge, the one-seeded Honey Locust (G.aquatica) has been found. It is a southern species. The other species of Honey Locust is quite common.

It seems that we should include in this list the Buck Thorn, Red Root (Ceanothus americana). This little shrub is just now attracting considerable attention, for a chemist in Decatur has discovered the active principle in the root and has named it Ceanothyne. This is said to be the most active vaso-constrictor known. During the revolution the soldiers used the leaves of this shrub as a substitute for tea. Another species of Buckthorn, the Carolina Buckthorn (Rhamnus carolinana), has been found at Grand Tower.

In the fall the roadsides and fence corners are brilliant with the red of Sumac of at least two species (Rhus capalone and glabra), but the uninitiated should look out for the poison kind. The little slender stubby species (R.aromatica) is to be found in the open woods. I see no reason why this interesting little shrub should not be included in the shrubberies about our homes. It is free from toxic properties.

Among other interesting shrubs are two Huckleberries (Vaccinium arboreum and V. vaxillans), and wild Hydrangea (H. arborescens) which are to be found along the river banks and shady cliffs. Along with these are to be found Blaider Nut (Staphylea trifolia), two species of Euonumus, Wahoo and Strawberry Bush (E. atropurpurea and E. americana), with the shrubby Bitter Sweet (Celastrus scandens). In the fall of the year the latter plant is sure to attract the atention of motorists passing through the hilly section.

So far as I know we have no climbing honeysuckle or species of Lonicera. Disappointed politicians are told "to go where the woodbine twineth". They will have to seek a hilly country farther to the east to find the woodbine. We have some interesting vines, however, as the southern River Grape (V. bipinnata), which has been

found at Grand Tower, and V. indivisa are not uncommon. The wild Yam (Dioscorea villosa) is common enough to attract the attention of travelers who find the curious pods and take them along to find out what they are. Several species of Smilax, some of which are called cat briers, are so plentiful that one often needs pruning shears to get through some of the thickets.

We have two species of Dutchman's Pipe (Aristolochia tomentosa and A. sipho), the first found at Grand Tower, but rarely have I seen the second. The butterfly that feeds on these is rather common, and for a time I thought the larvae fed on a related plant, wild Ginger (Asarun canadensis), till I found they would starve when placed on this common plant. They are better botanists than I am for I have not found either species of Aristolochia for a number of years.

One of the first things I noticed in coming from central New York to northern Illinois was the scarcity of annuals and herbaceous perennials in the woods. This is not true of the woods in the range of hills that cross the southern part. Here there is a blending of species of the northern and southern flora that sometimes results in new forms. Dodocatheon meadia of the prairies is replaced with a more delicate form, D. frenchii, that when grown beside the prairie form blooms two weeks later than D. meadia. The leaves of D. frenchii are broader, thinner and more lettuce-like. This species is to be found only under shaded cliffs. These cliffs contain two interesting Heuchera rugelii, growing out of crevices in shaded bluffs, and saxifraga forbesii, growing on moss-covered shelves at the base of the bluffs. According to late botanists the first is a southern sport and the latter a northern one.

There are too many interesting plants to be found here to take time to enumerate all of them. Synandra grandiflora of the north is met by Clitoria mariana of the south. Japan clover is coming in from the south and replacing our native species, lespedesa violacea. He who visits the woods and fields in fall or late summer will not try to identify the different species of Desmodium he has on his clothes, to say nothing of Agrimonia. The field is

rich in Asters and goldenrods, both in numbers and species.

The lower forms of plants life are well represented. The writer has found 24 species of ferns in Jackson County, and they are well represented in adjoining counties. It might be said that these cliffs and shaded retreats are the homes of mosses, and lichens are equally numerous. Besides the numerous forms of parasitic fungi that man has introduced into his cultivated plants, there are many interesting fungi. There are enough edible species to satisfy the most exacting tastes of mushrooms proper, and other edible forms, while the Amanitas are well represented, as several times they have furnished the undertaker with a job. And you do not always find a dead rat when hunting for carrion for we have several species of stinkhorn.

MISTAKEN NOTIONS OF SCIENTIFIC PHENOMENA AS THEY NOW EXIST AMONG AVERAGE CITIZENS

CLARENCE BONNELL, HARRISBURG TOWNSHIP HIGH SCHOOL, HARRISBURG

This is the result of an investigation whose purpose was to learn something as to the prevalence of false ideas concerning common, every day phenomena. It was believed that high school students, especially freshmen, would reflect the beliefs held in their homes and among their grown up associates. It may be assumed that the more modern training of these students, coming from the upper stratum of society, as a rule, has made them more intelligent than the average citizen concerning such phenomena as are here discussed, so that the result of the inquiry does not exaggerate the condition.

Ten statements were sent to fifty high schools in northern and southern Illinois, southern Indiana, and western Kentucky and Tennessee with the request that they be read to students without previous discussion or warning. It was suggested that students indicate by a show of hands whether they considered the statements true or untrue. The list was not sent to schools in Chicago or other very large cities because the topics dealt with matters some of which are not heard of by children of the large cities.

Returns were received from thirty-five groups of students, numbering in all fifteen hundred eighty-one children representing twenty-nine schools. A few schools made records from second, third or fourth year students instead of, or in addition to, freshmen, which reduced the relative number of affirmative answers. All answers are tabulated below:

Statement to Be Considered.	Number believing it true.	Number in doubt.	Percent believing it true.
1. There is a reptile called a hoop snake which takes its tail in its mouth and rolls like a hoop.	653	243	41.3
2. The growth of vegetables is influenced by the "time of the moon" when the seeds are planted	377	193	23.2
3. A man has one more rib than a woman since one of Adam's ribs was removed in creating Eve.	130	250	8.2
4. Hydrophobia may be prevented in one who has been bitten by a mad dog by applying a "mad stone" to the wound.	294	234	19.5
5. The heart beat is caused by the striking of the heart against the chest wall as it swings from side to side after the fashion of the clapper of a bell.	24	119	1.5
6. Warts may be removed by means of charms by some people; that is, some people have the power of causing warts to disappear by performing certain acts or saying certain things over them.	426	137	26.9
7. Malaria may be acquired by drinking water from wells, cisterns or reservoirs that have been contaminated with malaria.	940	199	59.4
8. When a mouse becomes fully grown, it is no longer called a mouse but is called a rat.	94	185	5.9

Statement to Be Considered.	Number believing it true.	Number in doubt.	Percent believing it true.
9. Wheat turns to cheat; that is, a farmer may sow wheat seed that is free from other seeds, and cheat will grow from some of the wheat seeds and appear at the harvest time.	207	417	13.0
10. A horse hair left in a watering trough may develop into a slender worm like animal called a "horse hair snake".	335	170	22.4

Thus it is seen that students answered that the statements were true, in numbers ranging from one and one-half per cent in one case to nearly sixty per cent in another. In addition, it must be remembered that an average of thirteen and a half per cent of them did not know whether the statements were true or untrue.

Replies were from these schools in Illinois:—Harrisburg, Cairo, Thebes, Fairfield, Enfield, Bridgeport, Opdyke, Centralia, Tamaroa, Zeigler, Murphysboro, Cornell, Galena, Oregon, Rochelle, Belvidere, and two from near Chicago that requested that the exact locality be suppressed. Also Sullivan, Corydon, Booneville, Princeton, Mt. Vernon and Spencer, Indiana; Paducah and Franklin, Kentucky; and Shelbyville and Union City, Tennessee, sent replies.

Locality seemed to have little to do with the kind of replies given. The seven northern Illinois schools were stronger in the belief in the moon's influence on vegetable growth, the clapper like beat of the heart, the mouse becoming a rat, and that wheat turns to cheat. The difference was slight on the questions of a woman's extra rib, charming away warts, and the existence of the horse hair snake. The South believed more strongly in the hoop snake and the mad stone and ran a little ahead of the more northern cities in the belief that malaria is caused from drinking water.

The conclusion is that there is yet much patient teaching of common-place biology to be done. When fifty-nine

per cent of high school freshmen, including some from higher classes, do not know that the mosquito is the only transmitter of malaria and when hydrophobia is thought by eighteen per cent of them to be prevented by the so-called "mad-stone", it is a sad commentary on the teaching of biological subjects. Maybe I should say that it emphasizes the want of teaching.

THE UTILIZATION OF FARM MANURE

H. J. Snider, University of Illinois

History reveals that shortly after the American Colonists became well established along the eastern coast they discovered that they must turn their attention to the preservation of the fertility of the lands from whence came their food supply. There are some records which show that even the American Indians, previous to the coming of the white man, used means of restoring fertility and increasing the productiveness of their corn fields. What was true of the original colonies, in this respect, has also been true of each successive settlement as the pioneers pushed their course westward across the continent. This civilization, as have civilizations in other parts of the world, established the fact that as lands are tilled and kept long under cultivation, they gradually lose their power of productiveness, and productiveness must be restored and maintained if the population thereon is to flourish and prosper.

Manure is usually the first material to be used in an effort to restore and maintain a productive soil. Lyman Carrier in his book, "Beginnings of Agriculture in America," cites incidents as early as 1630 where manure was used by colonists to increase the productiveness of their farm lands. In the same book is cited a record where a man by the name of Wm. Shipley of Wilmington, Delaware, in 1750 quoted on stable manure a price of 6½ cents for a single horse load, and 10 cents for a two horse load. King states (Farmers of Forty Centuries) that China is supporting a population of some 500,000,000 on an area smaller than the improved farm lands of the United States. The Chinese are cultivating and obtaining their food supply from lands which have probably been farmed for over forty centuries. The fertility of these lands has been maintained up until very recently, mainly by returning to the land a compost which is made up very largely of manure.

Lincoln in an address delivered at Milwaukee in 1859 apparently had in mind the preservation of fertility when he said, "For the last four years I do not believe the ground planted with corn in Illinois has produced an

average of twenty bushels. It is true that heretofore we have had better crops with no better cultivation; but I believe it is also true that the soil has never been pushed up to one-half its capacity." In the same speech he mentioned experiments with manure as one of the means by which may be grown better crops.

"The word manure is derived from the French 'manoeuvrer', to manipulate, to work, and in its earlier significance meant both tilling or working the land and adding to it materials designed to increase its productiveness. In America we sometimes speak of such crops as green manure, but with this exception, we limited the words manure and manuring to the excreta of animals and their use for soil enrichment." (Thorne Farm Manuares, p. 81.) In the following discussion manure will mean the excreta of farm animals with straw or other material used for bedding, or as an absorbent.

Statements from various publications give some idea of the volume of manure produced and its probable value. Regarding the waste of manure in the United States, Director Thorne (Farm Manures, p. 150) makes the following statement: "It is a very conservative estimate to place the waste of this manure under prevalent systems of management at 25 percent, or $50,000.00 annually. It is probably more nearly twice that amount." Professor Roberts (Ky. Sta. Circ. 164) states that farms in Kentucky produce 10,000,000 tons of manure annually, half of which is wasted, representing a probable loss of $15,000,000. Professor Wiancko (Ind. Sta. Bul. 222) states that one-third of the manure made on Indiana farms each year is wasted by improper methods of conservation and handling, representing an annual loss of approximately $26,000,000. The above stated sums, while in some degree representing paper losses, yet serve to show the immense potential value of farm manure when properly conserved and utilized on lands for food production.

In Illinois manure is a by-product of livestock farming, and its ultimate value depends upon its ability to increase productiveness when used for soil enrichment. Manure in this state does not have a definite market value, nor is

there in general use any fixed standards for computing its value. Chemical analysis might furnish a basis for a value, but the composition varies greatly and the chemical elements in manure do not have the same influence on crop yields when used on different soil types and with other variable conditions. The increased crop yields as a basis for manure valuation are subject to variation. The increased yield obtained will vary with the composition of the manure, the amount used, soil type, kind of crop grown, climate and other factors. The influence of these variations on value might be determined by observing results under these various conditions. Values based on actual production may be determined by resorting to experimental data obtained from various sections of this state, and also there is data available for almost every state in the Union and for states in different parts of the world. In early times manure, being about the only known fertilizing material, came to be generally used in early experiment station work. The scientific literature on manure and subjects relating to its use is voluminous. There seems to be no detail regarding its relation to agriculture that has not been investigated and thoroly reported.

In this state during the past twenty years manure has been used for soil enrichment in many field experiments. These experiments have been conducted on different soil types and with many variable conditions. In these field tests it has been the aim to utilize manure in much the same manner as it is used on the average farm. From a summary of these field results may be obtained a fairly accurate valuation of farm manure.

The Illinois manure experiments are based upon the idea that in a system of livestock farming manure may be applied to land at a rate corresponding to the rate of crop production. This plan allows one ton of manure for each ton of crops consumed. The Ohio Experiment Station shows that when livestock is fed on a cement floor under shelter, 1.3 to 1.5 tons of manure are produced for each ton of feed and bedding used. Illinois farm conditions as a rule do not allow such care in the preservation of manure; so it seems entirely possible that the average

farm loss would amount to one-fourth to one-third of the total under prevailing practice.

In the following tables and discussion there are presented results from twelve Illinois experiment fields located on large and important soil areas of the state. The Brown Silt Loam Prairie soil is the predominating type of the fertile corn belt of Central and Northern Illinois. The Gray Silt Loam Prairie soil is the prevailing type in South Central Illinois. The Yellow-Gray Silt Loam timber soil represents the more rolling lands of extreme Southern Illinois.

The tables are arranged to show the crop yields on manured and untreated land; also the increase in yields due to manure. Manure is applied for the corn crop in the rotation and at the rate of a ton of manure for each ton of crops removed. An amount sufficient to supply that rate for four years is put on at each application. The years represent the crop averaged and the length of time manure has been applied for each crop. The average ends with 1924.

Grain and hay values used as follows: Wheat, $1.00; corn, 75 cents; oats, 40 cents; hay, $15 per ton; seed cotton, 7 cents a pound. Manure values are based on these prices. No value is placed on straw and corn stover.

MT. MORRIS EXPERIMENT FIELD—(Ogle County.)

Brown Silt Loam, Prairie Soil.

Manure applied at average annual acre rate 2.61 tons.

	Wheat 10 Yrs.	Corn 13 Yrs.	Oats 12 Yrs.	Clover 11. Yrs.
Land manured	27.6 bu.	58.1 bu.	69.1 bu.	5,000 lbs.
Land untreated	23.1 bu.	43.8 bu.	59.4 bu.	4,080 lbs.
Increase for manure	4.5 bu.	14.3 bu.	9.7 bu.	920 lbs.

Manure value per acre, $6.67
Manure value per ton, 2.55

DIXON EXPERIMENT FIELD (Lee County)

Brown Silt Loam, Prairie Soil.

Manure applied at average annual rate 2.43 tons.

	Wheat 9 Yrs.	Corn 13 Yrs.	Oats 12 Yrs.	Hay 11 Yrs.
Land manured	25.4 bu.	53.0 bu.	63.4 bu.	4,520 lbs.
Land untreated	19.4 bu.	34.2 bu.	51.6 bu.	3,320 lbs.
Increase for manure	6.0 bu.	18.8 bu.	11.8 bu.	1,200 lbs.

Manure value per acre, $9.28
Manure Value per ton, 3.78

LA MOILLE EXPERIMENT FIELD (Bureau County)

Brown Silt Loam, Prairie Soil.

Manure applied at average annual rate of 3.23 tons per acre.

	Wheat 10 Yrs.	Corn 13 Yrs.	Oats 12 Yrs.	Clover 9 Yrs.
Land manured	39.0 bu.	57.2 bu.	72.2 bu.	5,880 lbs.
Land untreated	31.2 bu.	50.5 bu.	65.1 bu.	5,300 lbs.
Increase for manure	7.8 bu.	6.7 bu.	7.1 bu.	580 lbs.

Manure value per acre, $4.94
Manure value per ton, 1.53

URBANA DAVENPORT PLOTS (Champaign County)

Brown Silt Loam, Prairie Soil.

Manure at average annual acre rate 2.59 tons.

	Wheat 14 Yrs.	Corn 14 Yrs.	Oats 14 Yrs.	Clover 14 Yrs.	Alfalfa 12 Yrs.
Land manured	29.8 bu.	64.4 bu.	62.6 bu.	4060 lbs.	5420 lbs.
Land untreated	26.6 bu.	53.1 bu.	52.7 bu.	3560 lbs.	5280 lbs.
Increase for manure	3.2 bu.	11.3 bu.	9.9 bu.	500 lbs.	140 lbs.

Manure value per acre, $4.10
Manure value per ton, 1.58

CARTHAGE EXPERIMENT FIELD (Hancock County)

Brown Silt Loam, Prairie Soil.

Manure applied at average annual rate of 1.83 tons per acre.

	Wheat 10 Yrs.	Corn 13 Yrs.	Oats 12 Yrs.	Clover 11 Yrs.
Land manured	24.4 bu.	40.5 bu.	39.3 bu.	4,500 lbs.
Land untreated	20.3 bu.	33.6 bu.	34.0 bu.	4,280 lbs.
Increase for manure	4.1 bu.	6.9 bu.	5.3 bu.	220 lbs.

Manure value per acre, $2.96
Manure value per ton 1.62

CLAYTON EXPERIMENT FIELD (Adams County)

Brown Silt Loam, Prairie Soil.

Manure applied at average annual rate of 1.99 tons per acre.

	Wheat 10 Yrs.	Corn 13 Yrs.	Oats 12 Yrs.	Clover 11 Yrs.
Land manured	21.5 bu.	48.2 bu.	44.1 bu.	4,680 lbs.
Land untreated	16.8 bu.	31.3 bu.	36.1 bu.	3,960 lbs.
Increase for manure	4.7 bu.	16.9 bu.	8.0 bu.	720 lbs.

Manure value per acre, $6.71
Manure value per ton, 3.37

EWING EXPERIMENT FIELD (Franklin County)

Gray Silt Loam on Tight Clay, Prairie Soil.

Manure applied at average annual rate of 0.86 tons per acre.

	Wheat 9 Yrs.	Corn 14 Yrs.	Oats 13 Yrs.	Hay 12 Yrs.
Land manured	3.4 bu.	22.8 bu.	15.0 bu.	480 lbs.
Land untreated	1.9 bu.	11.2 bu.	10.2 bu.	380 lbs.
Increase for manure	1.5 bu.	11.6 bu.	4.8 bu.	100 lbs.

Manure value per acre, $3.50
Manure value per ton, 4.06

TOLEDO EXPERIMENT FIELD (Cumberland County.)

Gray Silt Loam on Tight Clay, Prairie Soil.

Manure applied at the average annual rate of .87 tons per acre.

	Wheat 7 Yrs.	Corn 12 Yrs.	Oats 10 Yrs.	Hay 9 Yrs.
Land manured	10.0 bu.	25.7 bu.	21.1 bu.	800 lbs.
Land untreated	8.6 bu.	20.4 bu.	17.7 bu.	580 lbs.
Increase for manure	1.4 bu.	5.3 bu.	3.4 bu.	220 lbs.

Manure value per acre, $2.05
Manure value per ton, 2.35

OBLONG EXPERIMENT FIELD (Crawford County)

Gray Silt Loam on Tight Clay, Prairie Soil.

Manure applied at the average annual rate of 1.05 tons per acre.

	Wheat 11 Yrs.	Corn 12 Yrs.	Oats 10 Yrs.	Hay 9 Yrs.
Land manured	11.2 bu.	28.7 bu.	23.0 bu.	1,260 lbs.
Land untreated	8.8 bu.	20.1 bu.	16.4 bu.	820 lbs.
Increase for manure	2.4 bu.	8.6 bu.	6.6 bu.	440 lbs.

Manure value per acre, $3.83
Manure value per ton, 3.64

RALEIGH EXPERIMENT FIELD (Saline Countyy.)

Yellow-Gray Silt Loam, Timber Soil.

Manure applied at average annual rate of 1.11 tons per acre.

	Wheat 9 Yrs.	Corn 14 Yrs.	Oats 13 Yrs.	Clover 12 Yrs.
Land manured	7.6 bu.	28.1 bu.	13.1 bu.	1,080 lbs.
Land untreated	5.7 bu.	14.7 bu.	10.0 bu.	800 lbs.
Increase for manure	1.9 bu.	13.4 bu.	3.1 bu.	280 lbs.

Manure value per acre, $4.14
Manure value per ton, 3.73

ENFIELD EXPERIMENT FIELD (White County.)

Yellow-Gray Silt Loam, Timber Soil.

Manure applied at average annual rate of .93 tons per acre.

	Wheat 8 Yrs.	Corn 11 Yrs.	Oats 11 Yrs.	Hay 10 Yrs.
Land manured	5.4 bu.	27.9 bu.	15.0 bu.	560 lbs.
Land untreated	4.4 bu.	18.8 bu.	11.7 bu.	460 lbs.
Increase for manure	1.0 bu.	9.1 bu.	3.3 bu.	100 lbs.

Manure value per acre, $2.33
Manure value per ton, 2.50

UNIONVILLE EXPERIMENT FIELD (Massac County.)

Yellow-Gray Silt Loam, Timber Soil.

Manure applied at average annual rate of 1.17 tons per acre.

	Cotton 9 Yrs.	Wheat 10 Yrs.	Corn 12 Yrs.	Hay 11 Yrs.
Land manured	328 lbs.	8.5 bu.	24.0 bu.	1,520 lbs.
Land untreated	192 lbs.	4.2 bu.	19.0 bu.	1,280 lbs.
Increase for manure	136 lbs.	4.3 bu.	5.0 bu.	240 lbs.

Manure value per acre, $4.61
Manure value per ton, 3.93

The crop yields and values in these tables do not take into consideration the residual manure remaining in these soils. It is evident that if these soils were cropped until the manure was entirely extracted the value per ton of manure would be considerably increased. This is substantiated by some evidence from the Woburn (England) Experiment Station. In this experiment 40 tons of manure were applied during a five year period, and the land cropped for thirty years. The first ten years (1877-86) this manure value based on crop yields was $1.29 per ton. For the twenty year period (1877-96) the ton value was $2.93. The thirty year period (1877-1906) the ton value was $3.83. This test shows the possibility of the residual value of manure. (Jour. Roy. Agr. Soc. Eng. V. 39 to 67.)

The following table summarizes the average tons per acre applied annually on the soil types indicated, and the

acre and ton value of manure based on production. Each section of the state is represented by three experiment fields.

	Tons Applied	Acre Value	Ton Value
Brown Silt Loam Northern Illinois	2.76	$ 6.96	$ 2.62
Brown Silt Loam Central Illinois	2.14	4.44	2.19
Gray Silt Loam South Central Illinois	.93	3.13	3.38
Yellow-Gray Silt Loam Extreme Southern Illinois	1.10	3.56	3.39

The above table and summary indicate that on an average Illinois corn belt land manure as a by-product is of sufficient value to warrant considerable care in its use and preservation. The amount which may be returned to these lands is such as to make it a very important factor in maintaining soil fertility.

The results show on the lighter soils of Southern Illinois that manure is very valuable. However, the present production of these soils is so limited that there is little prospect of maintaining and building up fertility by the use of manure alone.

Investigations show as a fertilizer, although ancient and long used, manure is still accepted and generally sought after for soil improvement. Its use does materially increase food production on Illinois soils. Its money value when measured by crop yields is such as to make it a valuable by-product of livestock farming. These values are such that farm equipment necessary for a more careful conservation of manure would likely be profitable.

The conservation of soil fertility and the production of an adequate food supply are very closely identified. At the present stage of our civilization there is a greater possibility of increasing the amount of food material produced per acre than there is of increasing the acreage suitable for production. With the tendencies of population to increase and concentrate in towns and cities, along with other social and economic tendencies, there is considerable prospect for a possible food shortage sometime in the future. Efforts to create more productive soils will render the food shortage less acute if that state of affairs ever arrives.

CONTRIBUTIONS TO THE FLORA OF HANCOCK COUNTY, ILLINOIS

FRANK C. GATES, STATE AGRICULTURAL COLLEGE, MANHATTAN, KANSAS

The following paper is the result of the author's study of the flora of Illinois as exemplified in Hancock County, during 1916, 1917 and 1918. It is obvious that this list of over 650 species is not complete, but it is thought desirable to have it in printed form so that it will be available for the use of others studying the flora of Illinois. The collections that were made are at present distributed among the herbaria of Carthage College, the Field Museum of Natural History, the University of Illinois and the Missouri Botanical Garden.

Hancock County is located in the west central part of Illinois, bordering the Mississippi River. For the most part, the county is upland covered over with glacial till. It is dissected by various streams, several of which rise in the county. The largest is Crooked River, a stream of perhaps 40 feet in width with steep muddy banks, normally bordered by lowland woods.

The soil is a heavy black loam over most of the county, the conspicuous variation being in the bottom lands along the Mississippi River south of Warsaw and in the vicinity of Dallas City where sandy and gravelly deposits have been made in recent times by the river. Between Warsaw and Hamilton, limestone comes to the surface in bluffs. These possess excellent fossiliferous layers.

At the time white men came into the county, most of it was vegetated by prairie except in spots along the streams more or less protected from fire, where woodland of the central deciduous hardwood forest province type was present. At the present time most of the prairie land is under cultivation except for patches here and there along fence rows, in corners and along railroad tracks. Such prairies as do exist are most frequently characterized by the big bluestem *(Andropogon furcatus)*. The forested areas are practically limited to along streams, where however they are tending to increase markedly both in density and extent, due in part

to protection from fire and the policy of maintaining river bank areas in forests to prevent active erosion into fields which would otherwise result. The forest, in the most suitable places, such as along the Mississippi River, contains sugar maple, pawpaw, Kentucky coffee tree, and basswood, expressive of the high type of development. Along the other water courses, the elm-soft-maple group of trees is normally present except in those newer invaded areas where willows are more usual. The woods that occur on the uplands, bordering streams and sometimes extending down the slopes to the flood plains, belong to the oak-hickory type.

In the list following, the nomenclature is essentially that of Britton & Brown's "Illustrated Flora", 2nd edition, except in the grasses where Hitchcock's "Genera of Grasses of the United States" Bull. 772, U. S. D. A. is used. The names and arrangement of families is that of Bessey's exemplification of the Natural System of classification.

Plants present only in cultivation are marked with an asterisk (*).

Phylum PTERIDOPHYTA.

OSMUNDACAE *(Royal Fern Family.)*

* Osmunda claytoniana.

POLYPODIACEAE *(Fern Family.)*

* Matteuccia struthiopteris.
Polystichum acrostichoides.
Dryopteris sp.
Adiantum pedatum.

Phylum CALAMOPHYTA.

EQUISETACEAE *(Horsetail Family.)*

Equisetum arvense.
Equisetum sp.

Phylum CYCADOPHYTA.

GINKGOACEAE.

* Ginkgo biloba.

Phylum STROBILOPHYTA.

PINACEAE *(Pine Family—in a broad sense.)*

* Pinus strobus.
* Pinus sylvestris.
* Pinus laricio.
* Picea canadensis.
* Picea parryana.
* Picea abies.
* Abies balsamea.
* Tsuga canadensis.
* Thuja orientalis.
* Thuja occidentalis.
Juniperus virginiana.

Phylum ANTHOPHYTA.

MONOCOTYLEDONEAE.

ALISMATACEAE *(Water-plantain Family.)*

Alisma subcordatum.
Sagittaria latifolia.

TYPHACEAE *(Cattail Family.)*

Typha latifolia.

LILIACEAE *(Lily Family.)*

Hemerocallis fulva.
Allium cernuum.
* Allium spp.
Allium canadense.
Erythronium americanum.
Erythronium albidum.
Quamasia hyacinthina.
Ornithogalum umbellatum.
* Yucca filamentosa.
Asparagus officinalis.
Vagnera racemosa.
Vagnera stellata.
Uvularia grandiflora.
Polygonatum commutatum.
* Convallaria majalis.
Trillium recurvatum.

Trillium nivale.
Smilax herbacea.

COMMELINACEAE *(Spiderwort Family.)*

Commelina sp.
Tradescantia reflexa.
Tradescantia pilosa.

JUNCACEAE *(Rush Family.)*

Juncus tenuis.
Juncoides campestre.

ARACEAE *(Arum Family.)*

Arisaema triphyllum.
Arisaema dracontium.

LEMNACEAE *(Duckweed Family.)*

Spirodela polyrhiza.
Lemna trisulca
Lemna minor.
Wolffia columbiana.

CYPERACEAE *(Sedge Family.)*

Cyperus strigosus.
Eleocharis acuminata.
Scirpus validus.
Scirpus fluviatilis.
Scirpus lineatus.
Scleria triglomerata.
Carex pennsylvanica.
Carex blanda.
Carex spp.

POACEAE *(Grass Family.)*

Bromus tectorum.
Bromus ciliatus.
Bromus inermis.
Bromus kalmii.
Bromus secalinus.
Festuca octoflora.
Festuca ovina.
Festuca sp.
Panicularia nervata.
Poa annua.
Poa pratensis.
Poa sylvestris.
Poa compressa.
Poa sp.
Eragrostis frankii.
Eragrostis purshii.
Eragrostis cilianensis.
Eragrostis pectinacea.
Eragrostis hypnoides.
Diarina festucoides.
Dactylis glomerata.
Agropyron repens.
Triticum aestivum
Secale cereale.
Elymus virginicus.
Elymus canadensis.
Elymus striatus.
Hystrix hystrix.
Hordeum nodosum.
Hordeum jubatum.
Lolium perenne.
Koeleria cristata.
Avena sativa.
Agrostis palustris.
Agrostis hyemalis.
Alopecurus geniculatus.
Phleum pratense.
Muhlenbergia schreberi.
Muhlenbeigia mexicana.
Muhlenbergia sp.
Sporobolus heterolepis.
Sporobolus spp.
Aristida spp.
Eleusine indica.
* Capriola dactylon.
Spartina michauxiana.
Bouteloua hirsuta.
Bouteloua curtipendula.
Homalocenchrus virginicus.
Homalocenchrus oryzoides.
Syntherisma sanguinale.
Panicum dichotomiflorum.
Panicum capillare.
Panicum miliaceum.
Panicum virgatum.
Panicum agrostoides.
Panicum scribnerianum.
Panicum latifolium.
Panicum spp.
Echinochloa crusgalli.
Chaetochloa verticillata.
Chaetochloa lutescenes.
Chaetochloa viridis.
Chaetochloa italica.
Cenchrus pauciflorus.
* Miscanthus sinesis.
Andropogon scoparius.
Andropogon furcatus.
Holcus halepensis.
Holcus sorghum.
Sorghastrum nutans.
Tripsacum dactyloides.
Zea mays.
* Coix lachryma-jobi.

AMARYLLIDACEAE *(Amaryllis Family.)*

* Nracissus pseudo-narcissus.
Hypoxis hirsuta.

IRIDACEAE *(Iris Family.)*

Iris versicolor.
* Iris germanica.
Sisyrinchium albidum.

DIOSCOREACEAE *(Yam Family.)*

Dioscorea villosa.

CANNACEAE *(Canna Family.)*

* Canna spp.

ORCHIDACEAE *(Orchid Family.)*

Cypripedium parviflorum.
Ibidium sp.
Aplectrum hyemale.

DICOTYLEDONEAE-AXIFLORAE.

MAGNOLIACEAE *(Magnolia Family.)*

* Magnolia sp.
* Liriodendron tulipifera.

ANONACEAE.

Asimina triloba.

RANUNCULACEAE *(Crowfoot or Buttercup Family.)*

Hydrastis canadensis.
Isopyrum biternatum.
Actaea alba.
Aquilegia canadensis.
Delphinium tricorne.
Anemone canadensis.
Hepatica acutiloba.
Syndesmon thalictroides.
Ranunculus abortivus.
Ranunculus sceleratus.
Ranunculus recurvatus.
Ranunculus acris.
Ranunculus septentrionalis.
Batrachium trichophyllum.
Thalictrum dioicum.
Thalictrum sp.
Clematis virginiana.

BERBERIDACEAE *(Barberry Family.)*

* Berberis vulgaris.
* Berberis thunbergii.
Caulophyllum thalictroides.
Podophyllum peltatum.

MENISPERMACEAE *(Moonseed Family.)*

Menispermum canadense.

LAURACEAE *(Laurel Family.)*

Sassafras sassafras.
Benzoin aestivale.

MALVACEAE *(Mallow Family.)*

Althaea rosea.
Malva rotundifolia.
Callirhoe involucrata.
Sida spinosa.
Abutilon abutilon.
Hibiscus trionum.

TILLACEAE *(Basswood Family.)*

Tilia americana.
Tilia heterophylla.

ULMACEAE *(Elm Family.)*

Ulmus americana.
Ulmus fulva.
Planera aquatica.
Celtis occidentalis.

MORACEAE *(Mulberry Family.)*

Morus rubra.
Morus alba.
Toxylon pomiferum.
Humulus lupulus.
Canabis sativa.

URTICACEAE *(Nettle Family.)*

Urtica gracilis.
Urticastrum divaricatum.
Pilea pumila.
Parietaria pennsylvanica.

GERANIACEAE *(Geranium Family.)*

Geranium maculatum.

OXALIDACEAE *(Oxalis Family.)*

Oxalis violacea.
Oxalis stricta.
Oxalis cymosa.

BALSAMINACEAE *(Jewel-Weed Family.)*

Impatiens biflora.
Impatiens pallida.

LIMNANTHACEAE *(False Mermaid Family.)*

Floerkea proserpinacoides.

LINACEAE *(Flax Family.)*

Linum usitatissimum.
Linum sp.

ZYGOPHYLLACEAE *(Caltrop Family.)*

Tribulus terrestris.

RUTACEAE *(Rue Family.)*

Zanthoxylum americanum.
Ptelea trifoliata.

SIMARUBACEAE *(Ailanthus Family.)*

Ailanthus glandulosa.

POLYGALACEAE *(Milkwort Family.)*

Polygala viridescens.

EUPHORBIACEAE *(Spurge Family.)*

Croton glandulosus.
Croton monanthogynus.
Croton texensis.
Crotonopsis linearis.
Acalypha virginica.
Ricinus communis.
Chamaesyce geyeri.
Chamaesyce maculata.
Chamaescye preslii.
* Dichrophyllum marginatum.
Tithymalopsis corollata.
Tithymalus cyparissias.
Poinsettia heterophylla.

HYPERICACEAE (*St. John's-Wort Family.*)

Hypericum mutilum.

VIOLACEAE *(Violet Family.)*

Viola pedata.
Viola papilionacea.
Viola sororia.
Viola sagittata.
Viola pedatifida.
Viola eriocarpa.
Viola pubescens.
Viola rafinesquii.

PAPAVERACEAE *(Poppy Family.)*

Argemone alba.
Sanguinaria canadensis.
Chelidonium majus.
Bicuculla cucullaria.
• Bicuculla eximia.
Adlumia fungosa.
Capnoides micranthum.

NYMPHAEACEAE *(Water-Lily Family.)*

Nymphaea advena.

CAPPARIDACEAE *(Caper Family.)*

Cleome sp?
Polanisia graveolens.

BRASSICACEAE *(Mustard Family.)*

Draba caroliniana.
Koniga maritima.
Camelina sativa.
Bursa bursa-pastoris.
Radicula palustris.
Radicula sp?
Armoracia armoracia.
Lepidium campestre.
Lepidium virginicum.
Thlaspi arvense.
Sophia incisa.
Erysimum officininale.
Norta altissima.
Conringa orientalis.
Barbarea sp?
Arabis sp.
Cardamine sp?
Dentaria laciniata.
Sinapie alba.
Sinapis arvensis.
Brassica nigra.
Brassica campestris.
Raphanus sativus.

CARYOPHYLLACEAE *(Pink Family.)*

Alsine media.
Cerastium vulgatum.
Cerastium longipedunculatum.
Moehringia lateriflora.
Agrostemma githago.
Silene antirrhina.
Lychnis alba.
Saponaria officinalis.

PORTULACACEAE (*Purslane Family.*)

Claytonia virginica.
Portulaca oleracea.
Portucala grandiflora.

AIZOACEAE *(Carpet-Weed Family.)*

Mollugo verticillata.

SALICACEAE *(Willow Family.)*

Populus alba.
Populus tremuloides.
Populas italica.
Populus deltoides.
Salix nigra.
Salix interior.
Salix discolor.
Salix tristis.
Salix spp.

PHYTOLACCACEAE *(Pokeweed Family.)*

Phytolacca americana.

AMARANTHACEAE *(Amaranth Family.)*

Amaranthus retroflexus.
Amaranthus hybridus.
Amaranthus spinosus.
Amaranthus graecizans.
Acnida tamariscina.

CHENOPODIACEAE *(Goosefoot Family.)*

Chenopodium album.
Chenopodium ambrosioides.
Chenopodium spp.
Cycloloma atriplicifolium.
Atriplex hastata.
Salsola pestifer.

POLYGONACEAE *(Buckwheat Family.)*

Rumex acetosella.
Rumex mexicanus.
Rumex altissimus.
Rumex crispus.
Rumex obtusifolius.
Polygonum aviculare.
Tovara virginiana.
Persicaria amphibia.
Persicaria muhlenbergii.
Persicaria lapathifolia.
Persicaria pennsylvanica.
Persicaria persicaria.
Persicaria punctata.
• Persicaria orientalis.
Tracaulon sagittatum.
Tiniaria convolvulus.
Tiniaria scandens.

NYCTAGINACEAE *(Four-o'clock Family.)*

Allionia linearis.
Allionia nyctaginea.

PRIMULACEAE *(Primrose Family.)*

Androsace occidentalis.
Steironema ciliatum.
Dodecatheon meadia.

PLANTAGINACEAE *(Plantain Family.)*

Plantago major.
Plantago rugelii.
Plantago lanceolata.
Plantago aristata.
Plantago virginica.

ERICACEAE *(Ericad Family.)*

Monotropa uniflora.

EBENACEAE *(Ebony Family.)*

Diospyros virginiana.

POLEMONIACEAE *(Phlox Family.)*

Phlox pilosa.
Phlox divaricata.
Polemonium reptans.

CONVOLVULACEAE *(Morning-Glory Family.)*

* Quamoclit quamoclit.
Ipomoea pandurata.
Ipomoea purpurea.
Ipomoea hederacea.
Convolvulus sepium.
Convolvulus arvensis.
Cuscuta paradoxa.

HYDROPHYLLACEAE *(Water-leaf Family.)*

Hydrophyllum virginianum.
Hydrophyllum appendiculatum.
Nyctelea nyctelea.

BORAGINACEAE *(Borage Family.)*

Cynoglossum officinale.
Lappula virginiana.
Mertensia virginica.
Lithospermum arvense.
Lithospermum latifolium.
Lithospermum carolinense.
Lithospermum linearifolium.
Onosmodium hispidissimum macrospermum.

SOLANACEAE *(Potato Family.)*

Physalis virginiana.
Solanum nigrum.
Solanum carolinense.
Solanum rostratum.
Solanum dulcamara.
* Solanum tuberosum.
* Lycopersicon lycopersicon.
Lycium halimifolium.
Datura stramonium.
* Petunia violacea.

OLEACEAE *(Olive Family.)*

* Syringa vulgaris.
* Syringa persica.
Fraxinus americana.
Fraxinus pennsylvanica.
Fraxinus quadrangulata.
Forestiera acuminata.
* Ligustrum vulgare.

GENTIANACEAE *(Gentian Family.)*

Dasystephana puberula.

APOCYNACEAE *(Dogbane Family.)*

Vinca minor.
Apocynum androsaemifolium.
Apocynum sp?

ASCLEPIADACEAE *(Milkweed Family.)*

Asclepias tuberosa.
Asclepias incarnata.
Asclepias sullivantii.
Asclepias exaltata.
Asclepias syriaca.
Asclepias verticillata.
Acerates floridana.

SCROPHULARIACEAE *(Figwort Family.)*

Verbascum thapsus.
Verbascum blattaria.
Linaria linaria.
* Antirrhinum majus.
Scrophularia marylandica.
Scrophularia leporella.
Pentstemon sp?
Collinsia verna.
Mimulus ringens.
Conobea multifida.
Ilysanthes dubia.
Veronica peregrina.
Veronica arvensis.
Leptandra virginica.
Castilleja sp?
Agalinis skinneriana.

BIGNONIACEAE *(Trumpet-creeper Family.)*

Bignonia radicans.
* Catalpa speciosa.

ACANTHACEAE *(Acanthus Family.)*

Ruellia strepens.

PHRYMACEAE *(Lopseed Family.)*

Phryma leptostachya.

VERBENACEAE *(Vervain Family.)*

Verbena urticifolia.
Verbena hastata.

Verbena angustifolia.
Verbena stricta.
Verbena bracteosa.
Lippia lanceolata.

LAMIACEAE (LABIATAE) *(Mint Family.)*

Teucrium canadense.
Teucrium occidentale.
Scutellaria cordifolia.
Scutellaria parvula.
Agastache nepetoides.
Nepeta cataria.
Glecoma hederacea.
Prunella vulgaris.
Dracocephalum formosior.
Leonurus cardiaca.
Stachys tenuifolia.
Salvia pitcheri.
Monarda mollis.
Hedeoma pulegioides.
Clinopodium sp?
Koellia virginiana.
Lycopus americanus.
Mentha piperita.

DICOTYLEDONEAE-CALYCIFLORAE.

ROSACEAE *(Rose Family.)*

Potentilla canadensis.
Potentilla monspeliensis.
Fragaria grayana.
Fragaria virginiana.
* Fragaria sp.
Drymocallis agrimonioides.
Agrimonia gryposepala.
Geum spp?
Rubus strigosus.
Rubus spp.
Rosa spp.

MALACEAE *(Apple Family.)*

Pyrus communis.
Malus coronaria.
Malus ioensis.
* Malus malus.
Amelanchier sp?
Crataegus crusgalli.
Crataegus spp.

PRUNACEAE *(Peach or Plum Family.)*

Prunus americana.
Prunus spp.
Amygdalus persica.

CASSIACEAE *(Senna Family.)*

Cercis canadensis.
Cassia medsgeri.
Chamaecrista nictitans.
Chamaecrista fasciculata.
Gleditsia triacanthos.
Gymnocladus dioica.

FABACEAE *(Pea Family.)*

Baptisia leucantha.
Baptisia sp.
Medicago sativa.
Medicago lupulina.
Melilotus alba.
Melilotus officinalis.
Trifolium pratense.
Trifolium hybridum.
Trifolium repens.
Amorpha canescens.
Petalostemum candidum.
Petalostemum purpureum.
Cracca virginiana.
Robinia pseudoacacia.
* Robinia hispida.
Meibomia grandiflora.
Meibomia bracteosa.
Meibomia spp.
Lespedeza capitata.
Lathyrus sp?
Glycine apios.
Falcata comosa.
Strophostyles helvola.

SAXIFRAGACEAE *(Saxifrage Family.)*

Penthorum sedoides.
Heuchera hispida.
Mitella diphylla.

GROSSULARIACEAE *(Gooseberry Family.)*

Ribes cynosbati.
Ribes missouriensis.

CRASSULACEAE *(Orpine Family.)*

* Sedum triphyllum.

HAMAMELIDACEAE *(Witch-Hazel Family.)*

* Liquidambar styraciflua.

PLATANACEAE *(Plane-tree Family.)*

Platanus occidentalis.

LYTHRACEAE *(Loosestrife Family.)*

Parsonsia petiolata.

OENOTHERACEAE *(Evening-primrose Family.)*

Isnardia palustris.
Epilobium sp.
Oenothera biennis.
Gaura parviflora.
Gaura biennis.
Circaea lutetiana.

HALORRHAGIDACEAE *(Water Milfoil Family.)*

Myriophyllum sp.

ARISTOLOCHIACEAE (*Birthwort Family.*)

Asarum canadense.
Asarum acuminatum.

CUCURBITACEAE (*Gourd Family.*)

Micrampelis lobata.
Sicyos angulatus.
* Citrullus citrullus.

RHAMNACEAE (*Buckthorn Family.*)

Ceanothus americanus.
Ceanothus ovatus.

VITACEAE (*Grape Family.*)

Vitis vulpina.
Vitis sp.
Ampelopsis cordata.
Parthenocissus quinquefolia.

CELASTRACEAE (*Staff-tree Family.*)

Euonymus atropurpureus.
Euonymus sp.
Celastrus scandens.

STAPHYLEACEAE (*Bladder-nut Family.*)

Staphylea trifolia.

THYMELEACEAE (*Mezereum Family.*)

Dirca palustris.

SANTALACEAE (*Sandelwood Family.*)

Comandra umbellata.

HIPPOCASTANACEAE (*Buckeye Family.*)

* Aesculus hippocastanum.
Aesculus glabra.

ACERACEAE (*Maple Family.*)

Acer saccharinum.
* Acer platanoides.
Acer saccharum.
Acer nigrum.
Acer negundo.

ANACARDIACEAE (*Sumac Family.*)

Rhus copallina.
Rhus hirta.
Rhus glabra.
Rhus trilobata.
Rhus radicans.
* Cotinus americanus.

JUGLANDACEAE (*Walnut Family.*)

Juglans nigra.
Juglans cinerea.
Hicoria pecan.
Hicoria cardiformis.
Hicoria ovata.
Hicoria alba.
Hicoria glabra.

BETULACEAE (*Birch Family.*)

Ostrya virginiana.
Corylus americana.
* Betula pendula.
Betula nigra.

FAGACEAE (*Beech Family.*)

* Castanea dentata.
Quercus rubra.
Quercus palustris.
Quercus velutina.
Quercus marilandica.
Quercus imbricaria.
Quercus alba.
Quercus macrocarpa.
Quercus bicolor.
Quercus sp.

ARALIACEAE (*Ginseng Family.*)

Aralia racemosa.

APIACEAE (*Carrot or Umbellifer Family.*)

Eryngium aquaticum.
Sanicula gregaria.
Daucus carota.
Washingtonia claytoni.
Washingtonia longistylis.
Chaerophyllum procumbens.
Deringa canadensis.
Pastinaca sativa.
Thaspium barbinode.
Taenidia integerrima.
Zizia aurea.
* Apium petroselinum.
Eulophus americanus.
Sium cicutaefolium.
Cicuta maculata.

CORNACEAE (*Dogwood Family.*)

Cornus stolonifera.
Cornus florida.
Cornus spp.

RUBIACEAE (*Madder Family.*)

Cephalanthus occidentalis.
Diodia teres.
Galium aparine.
Galium spp.

CAPRIFOLIACEAE (*Honeysuckle Family.*)

Sambucus canadensis.
Viburnum prunifolium.
Triosteum aurantiacum.
Symphoricarpos symphoricarpos.
Symphoricarpos racemosus.
* Lonicera sempervirens.
* Lonicera tatarica.

CAMPANULACEAE *(Bellflower Family.)*

Campanula americana.
Specularia perfoliata.
Lobelia cardinalis.
Lobelia syphilitica.
Lobelia spicata.
Lobelia leptostachys.
Lobelia inflata.

"COMPOSITAE" *Order* ASTERALES. *(Composites.)*

HELIANTHACEAE.

Polymnia canadensis.
Silphium perfoliatum.
Silphium integrifolium.
Silphium laciniatum.
Silphium terebinthinaceum.
Parthenium integrifolium.
Heliopsis sp?
Verbesina alba.
Rudbeckia triloba.
Rudbeckia subtomentosa.
Rudbeckia hirta.
Rudbeckia laciniata.
Ratibida pinnata.
Echinacea pallida.
Helianthus annuus.
Helianthus petiolaris.
Helianthus subrhomboideus.
Helianthus occidentalis.
Helianthus microcephalus.
Helianthus maximiliani.
Helianthus divaricatus.
Helianthus mollis.
Helianthus tuberosus.
Helianthus spp.
Ridan alternifolius.
Coreopsis tripteris.
Bidens comosa.
Bidens frondosa.
Bidens bipinnata.
Bidens aristosa.

AMBROSIACEAE.

Iva xanthiifolia.
Ambrosia bidentata.
Ambrosia trifida.
Ambrosia elatior.
Ambrosia psilostachya.
Xanthium commune.
Xanthium sp?

HELENIACEAE.

Helenium autumnale.
Boebera papposa.

INULACEA.

Antennaria spp.
Anaphalis margaritacea.
Inula helenium.

ASTERACEAE.

Grindelia squarrosa.
Chrysopsis.
Solidago ulmifolia.
Solidago canadensis.
Solidago rigida.
Solidago ohioensis.
Solidago spp.
Euthamia graminifolia.
Boltonia asteroides.
Aster novae-angliae.
Aster puniceus.
Aster sericeus.
Aster multiflorus.
Aster spp.
Erigeron philadelphicus.
Erigeron annuus.
Erigeron ramosus.
Leptilon canadense.
Leptilon divaricatum.

VERNONIACEAE.

Vernonia fasciculata.
Vernonia missurica.

EUPATORIACEAE.

Eupatorium purpureum.
Eupatorium perfoliatum.
Eupatorium urticaefolium.
Eupatorium coelestinum.
Kuhnia eupatorioides.
Lacinaria scariosa.
Lacinaria spicata.

ANTHEMIDACEAE.

Acillea millefolium.
Anthemis cotula.
Chrysanthemum leucanthemum.
Chrysanthemum balsamita.
* Tanacetum vulgare.
Artemisia annua.
Artemisia vulgaris.
Artemisia gnaphalodes.
Artemisia sp.

SENECIONIDACEAE.

Erechtites hieracifolia.
Mesadenia atriplicifolia.
Senecio sp.

CARDUACEAE.

Arctium lappa.
Arctium minus.
Cirsium lanceolatum.
Cirsium altissimum.
Cirsium discolor.
Cirsium hillii.
Cirsium arvense.
Cirsium spp.
* Centaurea cyanus.

LACTUCACEAE.

Cichorium intybus.
Krigia virginica.
Tragopogon pratensis.
Taraxacum vulgare.
Taraxacum laevigatum.
Sonchus asper.
Lactuca virosa.
Lactuca canadensis.
Lactuca villosa.
Agoseris cuspidata.
Nabalus sp.

PAPERS ON CHEMISTRY AND PHYSICS

CHLORINE FOR COLDS

H. C. KREMERS, UNIVERSITY OF ILLINOIS

A considerable amount of interest is being shown at the present time in the use of chlorine for colds and allied diseases. In many instances this interest is beginning to crystallize definitely in the appearance of "chlorine clinics", "chlorine chambers", "Coolidge treatments", etc. In every case the method depends upon the fact that small amounts of free chlorine in the atmosphere are beneficial for colds and general infectious diseases of the respiratory passages. It has perhaps been noticed by many chemistry teachers and students as well that exposure to excessive amounts of chlorine, causing rather severe irritation in the throat and nasal passages and even severe pains in the chest, is almost always followed by complete recovery by the following morning. It is now a fairly well established fact that such doses of chlorine act as a very efficient prophylactic, and subsequent infection is very much minimized.

A general cure for colds has been the mecca of the medical profession for many years. The real discovery, however, of a so-called general cure for colds is again due to the chemist. During the late war it was noticed that the soldiers on duty in the chlorine departments of the arsenals were much less susceptible to colds than the workers in departments where no chlorine was present. During the severe influenza epidemic of 1918-19 the above soldiers were almost entirely immune. As a result of this observation Charles Baskerville (J. Ind. Eng. Chem. *12*, 293-4) published a digest of correspondence with some twenty-five producers of chlorine. From this data it was found that some thirteen of the largest producers of chlorine reported that among the employees in their chlorine departments there was either an entire lack of infection or most of the cases were very slight. From the several reports of the committee on occupational diseases in the chemical industry (J. Ind. Eng. Chem. *12*, 439-40), [Science *50*, 50 (1919)], there is an overwhelming evidence that air containing small amounts of chlorine, bromine or iodine does have a very decided prophy-

lactic effect. Even such gases as sulfur dioxide were favorably reported on. It is also reported by one of the largest producers of bromine in this country that employees who have worked in the bromine departments for twenty-five years are at the present time in the very best of health and rarely ever are out for colds.

In the winters of 1920 and 1923 the University of Arkansas (Harrison Hale. J. Ind. Eng. Chem. *12*, 806 and *15*, 746) placed a chlorine chamber in operation for a few weeks at a time during influenza epidemics. The concentration of chlorine in the room was not constant. By analysis the amount of chlorine varied from .014-.088 milligrams per liter of air. Due to this high concentration, treatments lasted only 5 minutes each day. Some 800 treatments were given to 184 individuals. Only one of these individuals developed influenza during the epidemic which was severe enough to cause the authorities to close the public schools. In the winter of 1923 during a similar epidemic the treatments were again given in much the same way with results almost as favorable.

We are no doubt indebted to Colonel E. B. Vedder, Director of the Medical Research Division of the Chemical Warfare Service at Edgewood Arsenal, together with the help of Captain Sawyer (J. Am. Med. Ass. *82*, 764, 1924), for the greatest advances along this line. Most exhaustive researches have been carried out in connection with their chlorine chamber. The concentration of chlorine and length of exposure required to kill most of the common bacteria, when exposed on agar plates, were carefully worked out. The limits of chlorine concentration were,then also carefully worked out on both animals and human subjects. It was found for instance that .010 milligrams of chlorine per liter of air can be plainly perceived. Concentrations above .017 milligrams per liter will cause irritation of the throat in 10-15 minutes. .015 milligrams per liter of air can be tolerated by most individuals for at least one hour. As a result, this latter maximum practical limit has been selected by Colonel Vedder as most effective for the average individual. Concentrations below .014 have been found to be very much less effective. It is, of course, needless to say that

the chlorine chamber at Edgewood Arsenal is equipped with the best ventilating system whereby a constant volume of air is continually admitted to the room. The chlorine gas is admitted into this ventilating system. Samples of air are constantly withdrawn for analysis, and the amount of chlorine admitted, regulated according to analysis.

We are especially indebted to Colonel Vedder for the valuable data that he has obtained at Edgewood Arsenal. The treatments were not only carefully supervised but the actual cures effected were carefully recorded. The following tabulation made by Colonel Vedder follows:

Diseases	No. of Cases	Cured No.	Cured Per cent	Improved No.	Improved Per cent	No Change No.	No Change Per cent
Acute bronchitis	241	192	80.	47	19.5	2	.5
Acute laryngitis and pharyngitis	127	99	78.	24	19.	4	3.1
Coryza (colds)	388	288	74.2	91	23.5	9	2.3
Chronic bronchitis	47	34	72.3	12	25.5	1	2.1
Chronic laryngitis	2	2	100				
Chronic rhinitis	106	33	31.1	41	38.6	32	30.2
Whooping cough	9	8	88.8	1	11.1		
Influenza	11	9	81.8	2	18.1		
Total	931	665	71.4	218	23.4	48	5.1

The chlorine chamber of the Army Research Division in Washington, D. C., under the direction of Colonel Harry L. Gilchrist, M. D., Army Medical Corps, with almost as many cases treated shows an average of 45 per cent cured. Chart No. 2 shows this summary (Wis. Med. Jr. *5*, Oct., 1924).

CHART NO. 2.

Diseases	Males	Females	Total	Acute	Chronic	Treatments	Improved	Not Improved	Cured	Result Unknown	Percentage Improved	Percentage Not Improved	Percentage Cured	Percentage Improved Cured
Asthma	9	17	26	....	26	134	8	13	2	3	34	57	9	43
Acute bronchitis	74	44	118	118	....	380	45	7	54	12	42	6	52	94
Chronic bronchitis	29	21	50	....	50	250	17	9	21	3	34	19	47	81
Bronchiectasis	2	....	2	....	2	5	....	2	....	....	....	100	....	....
Catarrh	41	15	56	....	56	201	31	11	1	13	71	27	2	73
Coryza	373	92	465	465	....	862	170	19	234	42	40	5	55	95
Chronic colds	36	15	51	....	51	173	14	7	20	10	34	17	49	83
Hay Fever	7	9	16	....	16	38	2	13	....	1	13	87	....	13
Laryngitis	10	9	19	4	15	44	8	1	3	7	66	9	25	91
Pharyngitis	9	2	1	2	9	34	7	1	1	2	78	11	11	89
Ps oriasis	2	....	2	....	2	5	....	....	2	....	....	....	100	100
Chronic rhinitis	16	6	22	....	22	90	8	10	3	1	39	48	13	52
Sinus involvment	12	5	17	1	16	63	10	5	....	2	66	34	....	66
Whooping cough	28	17	45	....	45	231	19	2	19	5	47	6	47	94
	648	252	900			2510	339	100	360	101				

Results from the chlorine chamber of the Navy Dispensary at Washington, D. C. are said to be substantially the same as those obtained by the army doctors at Edgewood and Washington.

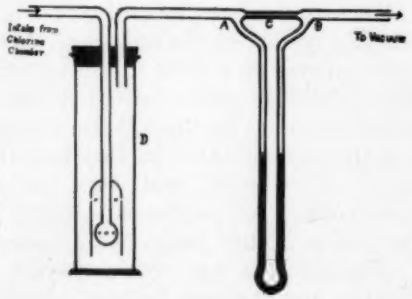
From recent press reports, Dr. Louis I. Harris from New York City claims that the treatment in New York City was unsatisfactory in the case of some 500 patients. Only 6.5 per cent cured were reported. Colonel Vedder points out that careful regulation of the concentration of the chlorine is as necessary for success as is the necessity of administering an ordinary medicine in definite amounts. It is also pointed out by Colonel Vedder and by Colonel Gilchrist that when the "chlorine cure" became better known to the general public, many individuals with chronic ailments of the respiratory passages, in many cases of a score of years standing, presented themselves for treatments and became discouraged after one or two treatments. These so-called hopeless cases were classed among those not cured or improved.

During a recent chemical show held at the Chemical Laboratory at the University of Illinois, on December 6th such a chlorine chamber was placed in operation. The room selected was an ordinary size class room. The ventilation was supplied in the ordinary way from the forced ventilating system of the building. An oscillating electric fan was placed on a shelf directly in front of the fresh air inlet. Chlorine was admitted to the room from an adjacent laboratory, the inlet tube terminating directly back of the electric fan. In this way the chlorine was constantly distributed and kept in circulation throughout the room. An additional electric fan placed at the opposite side of the room was a material aid to circulation. The chlorine was obtained from a cylinder of liquid chlorine and the gas bubbled through a wash bottle to serve as an index for the rate of flow. Air for analysis was continually withdrawn from the room and aspirated through 5 per cent KI solution, by means of a Folin ammonia absorption tube, 50 liters of air being drawn through this solution in 15 minutes. The liberated iodine was titrated with N/100 sodium thiosulfate solution. An analysis was thus made every 15 minutes and

the flow of chlorine regulated accordingly. No particular difficulty was experienced in keeping the chlorine concentration within the prescribed limits, even though visitors passed in and out of the room at frequent intervals. A two hour series of analysis ran as follows:

1:00	P. M.	.0146	milligrams per liter of air
1:15	P. M.	.0151	milligrams per liter of air
1:30	P. M.	.0153	milligrams per liter of air
1:45	P. M.	.0148	milligrams per liter of air
2:00	P. M.	.0149	milligrams per liter of air
2:15	P. M.	.0146	milligrams per liter of air
2:30	P. M.	.0154	milligrams per liter of air
2:45	P .M.	.0159	milligrams per liter of air
3:00	P. M.	.0150	milligrams per liter of air

The simplest and most inexpensive flow meter to indicate the rate of flow of air to be analysed is that shown in the accompanying diagram. This was constructed according to the flow meters designed by A. P. Benton (J. Ind. Eng. Chem. 2, 623): The absorption bottle D is shown with the Folin absorption tube in position. Due to the flow of the gases through the capillary C the difference of pressure set up at A and B is indicated by a difference in height of the mercury in the manometer tube. This apparatus was of course previously cali-



brated. Apparatus of slightly more elaborate design for introducing chlorine in definite amounts can be obtained from the National Research Laboratories, Westinghouse Building, Pittsburgh, and also from the Wallace and Tiernan Company, of New York City. The latter is of a portable nature containing a small cylinder of liquid chlorine and a connection whereby the gas is passed

through a glass cylinder containing salt solution. By means of a very simple siphon arrangement the chlorine is discharged into the atmosphere in pulsations, each pulsation containing 30 cc. of a gas.

It is necessary, of course, that several treatments be taken in order to completely cure a cold or to prevent influenza. It is suggested by Colonel Vedder that single treatments should not last for more than one hour, depending somewhat, of course, upon the individuals. Several persons took a treatment of one hour during the chemistry show and reported no particular discomfort at the end of the period although a slight irritation of the throat was noticeable.

Science teachers can be of distinct service to communities by installing such chambers as described above. No special equipment is necessary, but it is quite essential that the chlorine concentration be kept up to the amount suggested in this article. Lesser amounts are very much less effective. The question has also been asked by many individuals if the treatment could not be taken at home. It perhaps can be if proper supervision and precautions are taken. It must be remembered that chlorine in the concentrations used is quite corrosive and metal fixtures would tend to become corroded.

Those of us who are at all familiar with the chemistry of chlorine are aware of the fact that it is difficult to liberate the chlorine completely from hydrochloric acid by the action of ordinary oxidizing agents. Unless heat is applied, $MnCl_4$ is formed to some extent and the quantities of gas delivered very often fall short from calculated amounts. Home treatment by individuals thus becomes less satisfactory.

The approximate cost of 1 liter of chlorine gas as produced by the various methods may be of interest:

1	HCl on $KMnO_4$	$ .002 per liter
2	HCl on MnO_2	.0019 per liter
3	HCl on $K_2Cr_2O_7$	.003 per liter
4	HCl on $Na_2Cr_2O_7$	.0028 per liter
5	HCl on Bleaching Powder	.0018 per liter
6	Liquid Chlorine	.0011 per liter

No doubt special devices for taking individual treatments can and will be devised in such a manner that no

chlorine escapes into the room. On the other hand a chlorine chamber can be fitted up very easily as a reading room and lounge so that maximum comfort may be had by the individual. General experience at Edgewood and Washington has shown that better results are obtained by having the individual completely surrounded by chlorine gas. An interesting story book or two or a few popular magazines will help to popularize the treatment.

In conclusion it must be urged that if this great cure and preventive is to benefit the public at large as we hope it may, it must be kept out of the hands of the professional quacks and other mercenary individuals. Already fake nostrums are appearing on the market reputed to contain chlorine. On a community basis the cost of treatment per individual will be less than 5 cents. Some of the professional chlorine clinics are charging at least one dollar per treatment. The community science teacher can make himself of real service by enlisting the cooperation of the various health departments in this benefit to humanity.

THE METRIC SYSTEM FOR GENERAL USE

HARVEY A. NEVILLE, UNIVERSITY OF ILLINOIS

It is not the purpose of this paper to urge the superiority of the metric standards over our present jumble of weights and measures. All persons of scientific training are, by personal experience, able to make this comparison and are without exception in favor of the metric system. Furthermore, the literature on this phase of the subject is very extensive.

It is intended, however, to call to your attention: First, that the adoption of the metric system by law for general usage in this country is inevitable—in fact, imminent. Second, that it will be the duty of the educational system, particularly science departments, both in school and out, to teach the public to understand, employ and appreciate metric units. For this purpose some simple suggestions for teaching the metric system are offered.

The Britten-Ladd Bill, which provides for the exclusive use of metric standards, will be presented to Congress this year. There is every reason why this bill should pass. Every important organization or profession that employs weights and measures has expressed a preference for the metric system. Many have already changed, finding that they have economized in time, men and materials by so doing. Figure I shows that only the United States and Great Britain have failed officially to recognize the tremendous advantages of a simple yet universal system of measurement. Nor are the units used in these two non-metric countries of the same values. It is apparent that in the competition for international trade we must employ measurements understood by those countries whose trade we seek. This consideration is of especial importance with regard to the South American countries whose credit is good anywhere and whose trade is necessary for the prosperity of American industries.

The metric system has been before the legislators of this country since 1790, when George Washington in his message to the First Congress urged its adoption. Thomas Jefferson, to whom belongs most of the credit for our decimal monetary system, emphasized the need of a similar system of weights and measures, as have

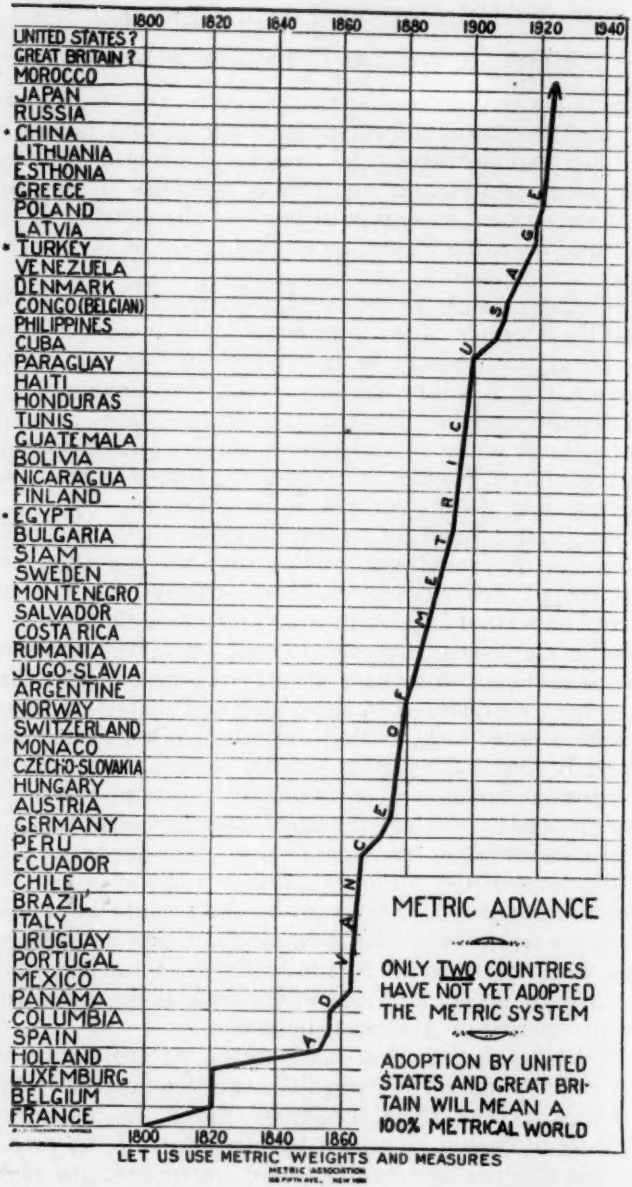

1800
1820
1840
1860
1880
1900
1920
1940
UNITED STATES?
GREAT BRITAIN?
MOROCCO
JAPAN
RUSSIA
• CHINA
LITHUANIA
ESTHONIA
GREECE
POLAND
LATVIA
• TURKEY
VENEZUELA
DENMARK
CONGO (BELGIAN)
PHILIPPINES
CUBA
PARAGUAY
HAITI
HONDURAS
TUNIS
GUATEMALA
BOLIVIA
NICARAGUA
FINLAND
• EGYPT
BULGARIA
SIAM
SWEDEN
MONTENEGRO
SALVADOR
COSTA RICA
RUMANIA
JUGO-SLAVIA
ARGENTINE
NORWAY
SWITZERLAND
MONACO
CZECHO-SLOVAKIA
HUNGARY
AUSTRIA
GERMANY
PERU
ECUADOR
CHILE
BRAZIL
ITALY
URUGUAY
PORTUGAL
MEXICO
PANAMA
COLUMBIA
SPAIN
HOLLAND
LUXEMBURG
BELGIUM
FRANCE
ADVANCE OF METRIC USAGE
METRIC ADVANCE
ONLY TWO COUNTRIES HAVE NOT YET ADOPTED THE METRIC SYSTEM
ADOPTION BY UNITED STATES AND GREAT BRITAIN WILL MEAN A 100% METRICAL WORLD
LET US USE METRIC WEIGHTS AND MEASURES
METRIC ASSOCIATION

FIG. I.

many other statesmen since that time. Contrary to the general impression, the metric system is not a French invention though France was the first country to adopt it legally. James Watt, the English scientist and engineer, originated and first published the decimal system of measurement using the four units now called Dollar, Meter, Liter, Gram. Undoubtedly, man first learned to count on his fingers, of which he has ten, so a decimal system is the natural outgrowth of the cave-man's adding machine. Furthermore, the Arabic system of numbers, one of the greatest inventions of all time, has ten ciphers so decimalization is its natural method.

With the Arabic numerals a child can perform with ease calculations that would have taxed the great mental powers of Julius Caesar, who had to use the clumsy Roman numerals. To the same extent a child in metric countries has the advantage of the American child in the arithmetic of weights and measures. As the *Chicago Tribune* puts the simile, in an editorial of February 3, 1925, the metric system is "a scientific system of weights and measures that compares with ours as a modern eight in line compares with a one lunger of a quarter century back."

It is with nothing less than sheer cruelty that we force upon school children the memorizing of absurd tables of measurements which few of us can (or would wish to) remember for long. Indeed, in this regard we probably feel grateful that the most amazing property of the human mind, according to an eminent psychologist, is not that it can remember a few things but that it can forget so much. No economy is more important than the economy of human time and effort, especially in the matter of education. In learning the metric system all there is to remember is given in Table 1—three units and six prefixes with decimal relations. An enormous amount of time and money—to say nothing of the patience of pupil and teacher—will be saved for education by taking our present "Tables of Weights and Measures" out of *Arithmetic* and putting them in *Ancient History*.

KILO	1000
HECTO	100
DEKA	10
METER LITER GRAM	
DECI	.1
CENTI	.01
MILLI	.001

TABLE I. The Metric System Condensed.

In addition to the fact that it is used by almost the whole world, the metric system has two intrinsic advantages. First, it is a *decimal* system, as just pointed out, and hence lends itself to slide rules and calculating machines and gives an easy relation to our decimal monetary system. Second, in the metric system the units of length, volume and weight are *interrelated* as shown in Figure 2. A volume of water, measured in cubic centimeters, may be conveniently used in place of a set of small weights. It is a simple matter to determine with a meter-stick the capacity of any container in liters by multiplying together its three dimensions expressed in centimeters and moving the decimal point three places to the left. Compare the relative amounts of mathematics involved in calculating the volume of the same box in liters and in quarts:

8 3/16 in.$\times$5¼ in.$\times$12⅛ in.$\div$57¾=? Quarts.

20.8 cm. $\times$13.34 cm.$\times$30.8 cm.$\div$1000=? Liters.

How many workmen, or even college freshmen, could cope with the common fractions in the first calculation? The absence of any simple relation among our present

units is illustrated in Figure 3. The edge of a cube having a volume of one quart is incommensurable.

In Figure 4 is shown an easy method of remembering the approximate differences between the units now in use and the metric units. The relations shown are accurate enough for most purposes. The adoption of the metric system will perform a very important service in removing the confusion due to the fact that certain units of the same name have different values. People in the United States who are engaged in trade with Great

FIG. II. The Relation of Length, Volume and Weight in the Metric System.

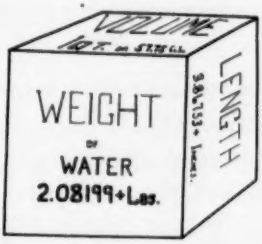


FIG. III. The Absence of Relation among our Present Units. The edge of a Quart cube is incommensurable.

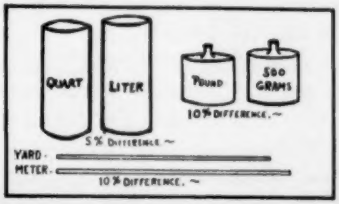


FIG. IV. The Approximate Difference between Present and Metric Units.

Britain or Canada are constantly distressed by the unfortunate situation shown in Table 2. Our own internal confusion is quite sufficient as illustrated in Table 3. Most people are ignorant of the existence of two kinds of quarts or of the fact that the quart for measuring solids is 16 1/3% greater than the liquid quart.

Metric units have already been adopted by our government for many specific purposes. They are used in all the scientific departments and as a basis for our coinage —as Table 4 will show. The carat used for weighing precious stones is officially defined as a metric weight. It seems extremely unfortunate that we should dissipate our educational energy by teaching two different systems of measurement. Arithmetic teaches the old units; the fundamental sciences in college or high school introduce and employ the metric units; engineering, medicine and other professions whose members have had thorough experience with metric units go back to the old units in their practice. From the standpoint of educational economy one system or the other should be discarded.

It is believed that this is a particularly opportune time to make the change to the international standards. A

1 LITER	
= 1.0567 LIQUID QUARTS (U. S.)	
= .9081 DRY QUART	
= .8798 IMPERIAL QUART (Brit.)	
IMPERIAL QUART 20% > LIQUID QUART.	
DRY QUART 16 1/3 % > LIQUID QUART.	
IMPERIAL GALLON	277 Cu. in.
STANDARD GALLON (U. S.)	231 Cu. in.
British Gallon = 1.2 U. S. Gallons.	
Hundredweight (U. S.)	100 Lbs.
Hundredweight (Brit.)	112 Lbs.

TABLE II.—Many of our units are confused. They differ from those of Great Britian, the only other non-metric country.

1 Lb. Butter = 16 Oz. = 7000 Grains = 454 Grams.
1 Lb. Gold = 12 Oz. = 5760 Grains = 373 Grams.
1 Qt. Beans = 1/8 Peck = 67.2 Cubic inches.
1 Qt. Molasses = 1/4 Gal. = 57.75 Cubic inches.
130 Kinds of Bushels now in Use in U. S.
391 Different Units have been called "POUND".
282 Different Units have been called "FOOT".

TABLE III.—More Confusion! If your grocer uses the same kind of quart measure for liquids and solids he is cheating you to the extent of 16⅔% on the solids.

FAMILIAR METRICS
1 CARAT weighs 1/5 g. or 200 mg.
1 "NICKEL" weighs 5 grams.
1 "DIME" is 1 mm. thick (or thin) and weighs 2.5 grams.
(Other silver coins accordingly)
A POSTAGE STAMP is 2 x 2.5 cm. and weighs about 50 mg.
1 DROP of WATER is about 1/20 cc. and weighs about 50 mg.
1 TEASPOONFUL is about 4 cc.
1 FLUID OUNCE is about 30 cc.
1 CUPFUL is 8 Fluid ounces.

TABLE IV.—The Metric System may best be taught by relating it to articles and units already in everyday use.

considerable proportion of our population is already familiar with metric units. Some have learned them from science courses in schools; some from service in the army —especially those who went to France. The great interest in popular science, particularly radio, has brought familiarity with metric terms to many. The recent

Olympic Games in France called to the attention of the world the metric units of distance at least. Many manufacturing companies—the Goodyear Rubber Company, for example—have found it an economic advantage to change to metric units on their own initiative. This answers the objection often raised that the change will be too expensive for industrial concerns. In most cases the change will not mean changing the size of anything but only the numbers by which it is labelled.

Practically all of the opposition to the metric system is due to misapprehensions based upon ignorance and to the strong factor of tradition. Ignorance can usually be cured by information; and the tradition becomes inverted when it is realized that the metric system is English and not French in origin, while the so-called English system really came from Germany who was progressive enough to discard it when she found something better.

YARD STICKS OF STREAM POLLUTION

R. E. Greenfield, Illinois State Water Survey

The fact that our streams are being polluted and that their natural beauty and economic value are thereby being destroyed is admitted by all. Many, but by no means all, realize the importance of this natural resource which we are using, a loss which in most cases is not balanced by corresponding or adequate gain.

As stated, everyone admits that the streams are being polluted, and yet when asked by what standards this pollution is judged or just what he means by badly polluted, moderately polluted or slightly polluted streams, the average person has some difficulty in making a reasonable answer and even the average scientist has only a hazy idea as to what he would do to determine this degree of pollution. We are all interested in stopping this destruction of our streams, but before we can go far in preventing or alleviating the trouble we must all understand just what we want stopped, what condition we want to prevent and what condition we wish to produce.

In other words we must set up a "yard stick" by means of which we can measure the degree of pollution upon any particular stream or place in the stream. The "yard stick" usually referred to in any general discussion is odor and appearance and indeed this is, in the main, the only one recognized in the courts. Such a measure of pollution is hardly delicate enough. The degree of pollution necessary to create a stench is so great that the normal stream life will have been entirely destroyed before such a state is reached, and yet to a considerable extent at present a stream is considered unpolluted until it has reach the state where it gives off a disagreeable odor or is disagreeable in appearance.

Considerable scientific work has been done in establishing a more delicate "yard stick" of pollution, and unfortunately considerable work must yet be done before thoroughly satisfactory and universally applicable standards can be adopted. It is always desirable in attacking a problem to use all of the tools at hand, and in the attack of the problem of clearing up a stream which has become or is becoming polluted by industrial or domestic

waste all of us should realize just what tools we have at hand and make use of all of them or at least the best of them.

It seemed to the writer that it would be worth while to summarize briefly what has been accomplished along these lines and to indicate what information can be collected concerning a stream in order that a fair conclusion as to its condition can be made or that a reasonable plan for protection can be laid out. In the preparation of this outline the following publications were used:

U. S. Public Health Bulletin 104, 131, 143.

U. S. Public Health Reports, reprints, 214, 594.

The Publications and files of the Illinois State Natural History Survey. Several publications of the Natural History Survey dwell particularly upon the subject and a large number are indirectly related to it.

Massachusetts Institute of Technology, R. S. Weston and Turner, *10*, Contribution from the sanitary research laboratory and sewage experiment station.

Kolkwitz and Marrson Mitteil. der Konigl. Landesanstant Heft I (1902).

Many other articles and bulletins are available bearing upon this subject and have been consulted to a certain extent. A good cross section of what is being done along these lines can be gained, however, by the reading of those cited. The material collected has been arranged in the form of a rather brief outline. This has been prepared with headings and sub-headings in such a way as to indicate relatively the importance of the different items. Brief remarks concerning certain items are included in the outline. The arrangement of the material has been influenced to a considerable extent by this Division's experience in the joint investigation of the Illinois River carried on by the Illinois Natural History Survey and the State Water Survey for a number of years past.

INFORMATION OF VALUE IN DETERMINING THE STATE OF POLLUTION OF A STREAM

I. Statistical Information.

1. Data of use in judging the amount of pollution entering.

   A. Total number of people living on land drained by the stream.
      a. On the stream proper.
      b. On its tributaries.

   B. Fraction of people served by sewers.
      a. On the stream proper.
      b. On its tributaries.

      Note: Due consideration should be taken of sewage treatment and distribution of the population in this tabulation.

   C. Industries producing organic wastes. If possible the extent of these wastes should be evaluated in terms of equivalent population.

   D. Industries producing inorganic wastes or other wastes impossible to evaluate in terms of equivalent population. The possible effect of such wastes should be considered carefully.

2. Hydrographic data of use in judging the ability of the stream to dispose of the polluting material entering it.

   A. All available gage readings.

   B. All available discharge measurements.

   C. The relation of the discharge to gage heights of several of the more suitable gages should be determined if possible, in order that discharge can be calculated for periods when measurements are not available.

   D. Area of watershed drained and run off.

E. By any means available the time of flow through all sections of the river should be estimated. This is more important than distance of flow in considering self- purification.

F. All special features such as dams which cause aeration and pooling, points of turbulence, or of especially slow flow, variations in depth or exposure to special or unusual climatic conditions should be observed. Such information may often be useful in explaining or predicting unusual conditions of self-purification.

II. Direct Observations of the Stream.—In this work it is desirable to make such determinations as will serve as indices of, first, the amount and character of polluting material entering or present in the stream; second, the success with which the wastes are being disposed of without detriment to the economic value of the stream; and, third, to give a picture of the relative condition and changes taking place in the stream at various points with a view to anticipating conditions which would affect the value of the stream. The order in which the main groupings of this section are arranged should not be taken as an index of their relative importance.

1. Chemical.

A. Physical; Turbidity, Color, Suspended matter and appearance of stream and bottom muds.

a. Dissolved oxygen of stream itself. Probably the most useful single method in determining the success with which the stream is disposing of the pollution.

b. Biological oxygen demand. Useful in determining to what extent introduced pollution has been destroyed.

C. Nitrogen Determinations.

a. Nitrates and Nitrites.

b. Free Ammonia.
c. Total Organic Nitrogen.

D. Other Chemical Tests. Many of the tests in this group are of use only in special cases.
a. Oxygen Consumed.
b. Mineral content of the water.
c. Chemical analysis of the mud.

2. Biological.—The ability of certain groups of organisms to select certain optimum zones with respect to conditions of pollution makes possible the selection of organisms wheih serve as indices of different degrees of pollution.

A. Investigations of the Water.
a. Observation of the occurrence of fish. Many fish are quite sensitive to pollution.
b. Plankton studies. Since the various microscopic forms exhibit varying tolerance to pollution some constitute fairly successful indices of conditions.
c. Observation of higher plants and animals

B. Investigation of the Bottom.
a. Examination of the bottom muds identifying the worms, insect larvae, shell forms, etc. Many of these organisms have definite degrees of tolerance to pollution, some being clean water forms while other prefer very putrid conditions.
b. Collection and identification of other bottom forms such as mussels, sponges, etc. Some of these constitute very good index organisms.

3. Bacteriological Study.—Much of this work is of especial interest in the consideration of the effect of the pollution on water purification plants.

A. Total Count. Often used both as an index of pollution and of the extent of self- purification.
   a. On nutrient agar 31½°C.
   b. On gelatine 20°C. used rather less than several years ago.

B. Estimation of B. Coli. Used much as in the total count.

C. Special studies on anaerobes and other special groups both in the water and in the bottom muds. While such work would seem to offer considerable possibility it has as yet not been very productive of information.

SUMMARY

The practice of dumping polluting wastes into our streams until they stink before any remedial or preventive measures are taken is unsatisfactory, since before such a state is reached all of the normal stream life, fish, etc. are totally destroyed or driven away. An idea as to the extent of the pollution may be arrived at as follows:

First, by collecting information concerning the amount and nature of wastes entering the stream. This information combined with a knowledge of the size of the stream and a knowledge from experience of the effect of waste on other streams may be used in determining the probable effect on the stream in question.

Second, an investigation of the life of the water and bottom muds will reveal changes from the normal flora and fauna which serve as indices of the effect of the waste on the stream.

Third, chemical and bacteriological tests, if taken properly and with sufficient frequency, indicate the effect the wastes are having on the stream and the success with which they are being destroyed.

SOME PROBLEMS OF THE CHEMISTRY TEACHER

G. M. Browne, State Normal University, Carbondale

We live in a world of chemical changes, at a time when the chemist's is the guiding mind of human contact with the material world. This century is the Chemical Age of the World's History. That man will be happiest who best understands the chemistry of himself and of the world about him. It therefore behooves us to spread a knowledge of chemistry.

The problems of the chemistry teacher may be classed into two groups: 1st, what to teach, and 2nd, how to teach. It is the choice of the writer of this paper to consider only the problem of what to teach. The subject of chemistry is now so large that no one person may hope to know it all. Topics must be chosen from this vast array depending upon what the student wishes to do in life. Our teachers of chemistry may be grouped into High School, College, Technical School, and University teachers. Each group has its own problem of what to teach. Let us begin with the High School teacher. He has pupils who will end their school days when they leave the High School. A second group will take the examination for teaching, and become teachers of physiology, geography, nature study, and elementary agriculture. A third group, the smallest, will go to college.

Chemistry is a useful subject and therefore every topic studied must by its usefulness justify the time spent upon it. What topics are best suited to these three classes of high school students? Let us consider the class that leave school to enter the ordinary walks of life. These students need as many of the facts of every day chemical experience as possible. Chemical theories have little value to such students. They need the facts so grouped as to be easily remembered. They need to know the effects of air, water, salt, and the common alkalies on the various metals in common use, the chemistry of food, of digestion, of respiration, of soap, and of some of the more common carbon compounds.

The second group of high school students, those that are to enter the teaching profession, of whom there are between 4000 and 5000 in Illinois each year, need all that the first group need and also the chemical foundation for the teaching of geography, physiology, and elementary agriculture. They need a vast knowledge of the chemistry of air, water, carbon dioxide, acids and minerals. They do not need much chemical theory or chemical arithmetic.

The needs of the third or college preparatory group are at the present time unknown; at least the colleges of the North Central Association have not solved the problem and most of them teach chemistry to the freshman class as if freshmen had never heard of chemistry.

Let us consider if there are not some of the topics usually taught to high school students that could be omitted without loss to the student's after-life activities, and the time saved used to better advantage. May not the chapter on Physical and Chemical Changes be left out? Do even you always know whether a given change is chemical or physical? And what difference does it make which you call it? Why devote time in the high school to the study of Boyle's and Charles' laws? Even if they were true the student may never have need to use them unless he goes to college, and he will have forgotten them long before that time comes and must relearn them. Where in the experiences of a wife and mother will a woman be helped by a knowledge of the periodic law, or of atomic numbers, or of the electron theory of the structure of the atom? Will a farmer raise better cows, pigs, oats, apples, or garden truck after he has spent hours in the study of the radio activity of uranium and thorium and the degeneration of one of them into radium and both into isotopes of lead? Had he not better spend his time learning the properties of common lead and the effects of lead arsenite on insects, animals, and plants? How useful to him is the knowledge of the structure of a factory for the manufacture of sulfuric acid by the chamber process compared to the knowledge of the effects of an excess of sulfuric acid in a super phosphate on his soil?

If some of those topics that belong to the advanced courses were left out, could not the time be used for the study of fuels and of the more important carbon compounds? The Technical Schools and Teachers Colleges have solved their problem of what to teach much better than have the High Schools, tho there is much yet to be done. The technical schools have labored with an eye on the completed product and I take off my hat to them.

What the Colleges shall teach to freshmen has about as many answers as there are teachers, and it looks to an outsider as if the answer is not yet in sight. Nearly all our teachers of chemistry in our high schools are college graduates, and 90% of them either take some high school text and follow it blindly or try to teach the high school children what they themselves were taught in their freshman year. The colleges have not yet solved the problem of what to teach prospective teachers of chemistry in the high schools.

If we agree that there is room for improvement in the choice of subject matter for High School Chemistry, what are we going to do about it?

CONTROL OF SUCCESSIVE IONIZATION BY COLLISION IN A PHOTO-ELECTRIC CELL

J. TYKOCINSKI-TYKOCINER, UNIVERSITY OF ILLINOIS

A gas-filled Photo-electric Cell as used for photometry[1] or for the reproduction of sound[2] consists of a cathode covered with a layer of alkali metal and an anode at a distance of about 2-3 cm. The sensitiveness of the cell achieves its largest value for an optimum pressure of the gas. Considering the influence of potential, the sensitiveness of the cell increases exponentially with the voltage applied to the electrodes, revealing the characteristic phenomena of ionization by collision.

In practical application of the cell, a limit is set to the value of the permissible potential by the instability of the current passing the cell when the critical voltage is approached. At this stage a visible, independent discharge establishes itself, which usually destroys the sensitiveness of the cell and endangers the delicate current measuring instrument.

The present investigation is the result of an attempt to overcome these deficiencies. It was found that by the application of a thermionic valve the current through the cell can be stabilized, and that by increasing some of the dimensions of the cell, a larger photo-electrically excited current can be obtained.

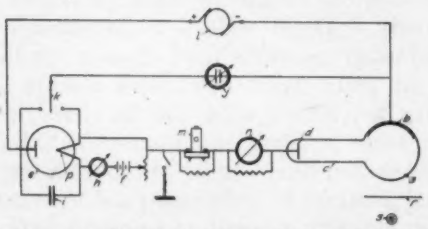


FIG. 1. Application of a Thermiamic Tube in Series with a Photo electric cell.

One of the arrangements used in this investigation is shown in Figure 1. The photo-electric cell (a) consists of a bulb, the lower part of which is silvered and covered

[1]Kunz, Jacob and Stebbins, Joel, On the Construction of Sensitive Photo-electric Cells. Phys. Review, Vol. 7, 1916, p. 62.

[2]Tykocinski—Tykociner, J.—Photographic Recording and Photo-electric Reproduction of Sound. Trans. Soc. Motion Picture Eng. Vol. 16, 1923, p. 90.

with a layer of potassium (b). This light-sensitive layer metallically connected with a platinum wire and sealed in the glass bulb forms the cathode of the cell. An aluminum disc anode (d), 1 cm. in diameter, was sealed in a side tube (c) at a distance of 10 cm. from the cathode. The cell was filled with Helium at a pressure of about 0.01 mm. The Thermionic device (e) consisted of a Kenotron rectifying tube (Type UV-201) the filament (p) of which was heated by the battery (f). The heating current was controlled by the rheostat (g) and measured by the ammeter (h). A condenser (i) connected parallel to the Kenotron, having a capacity of about 2500 mmf., served to minimize the influence of the variable tube capacity due to space charges upon the measurements of potential at the cell. This potential was measured by means of an electrostatic voltmeter (j). A switch (k) served to connect the voltmeter either across the motor generator (l) or across the cell (a). Between the anode (d) of the cell and the heated cathode (p) of the Kenotron (e) a sensitive reflecting galvanometer (m) and a less sensitive current-measuring instrument (n) were introduced, which allowed the measurement of a large range of currents passing through the cell.

In order that a current can flow in this circuit, the cathode of the photo-electric cell has to be illuminated from a source of light (s) and the filament (p) of the high vacuum thermionic valve must be heated. Thus both cathodes have to supply the electrons which carry the current. However, the total number of thermions emitted depends only on the temperature of the filament, while the number of ions in the photo-electric cell depends in addition to the intensity of the light source also on the number of collisions taking place between the photo-electrons and molecules on their motion towards the anode. For a constant gas pressure and constant potential between the electrodes, successive collisions will take place only in case the distance between the electrodes is considrably larger than the average free path of the photo-electrons necessary for ionization. The dimensions of the cell were therefore chosen so that possibly large currents could be produced by successive ionization along the path towards the anode.

The current in the circuit, passing the cell and also the valve, is limited by the ions produced in both of them. If in one of them a smaller number of carriers will be produced than in the other, the current which can establish itself in the circuit will be limited to that corresponding to the smaller number. No amount of ions produced in excess in one of the tubes can contribute to the current in the circuit.

By varying the filament current of the valve (e) we can control the maximum current which can flow in the circuit. Instead of using a two electrode thermionic tube, a triode tube can be applied in which the potential of the grid can be regulated by means of a battery and potentiometer. With such a tube the current in the circuit can be controlled at a constant filament current. In both cases the role of the thermionic tube is (1) to limit the maximum current in the circuit, (2) to stabilize the discharge and (3) to make possible very gradual variations of current without allowing discontinuous transformations of discharges to take place in the cell (a).

Much higher potentials can be applied to a photo-electric cell of this kind. It was found possible to use the tube at a critical potential when a visible glow discharge is produced. Due to the stabilizing action of the valve (e) this glow-discharge can be maintained for a long time without appreciably changing the sensitivity of the cell. The currents obtainable by these cells with the described arrangement are of the order of a few milliamperes.

One of the advantages in using a valve in series with a photo-electric cell or other vacuum tubes is the possibility it offers for the study of current-voltage characteristics, especially in regions where sudden changes from one form of discharge into another take place.

In Figure 2 the characteristic of the photo-electric cell described above is reproduced.

The method of obtaining the characteristic curves differs from the usual one in that instead of varying the electromotive force of the direct current generator (l) a constant potential difference is applied across the combination of a thermionic valve and a photo-electric cell. The constant voltage is chosen so that it is somewhat higher than necessary to produce a visible discharge in

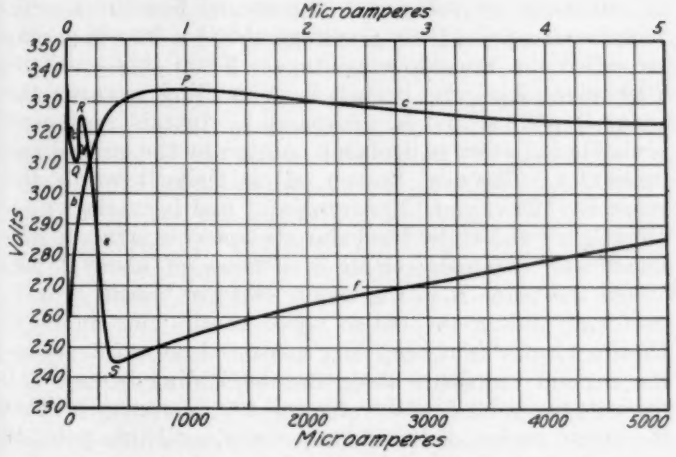


FIG. II. Current Voltage Characteristic of the Photo electric cell.

the cell. How this constant potential difference is divided between the cell and valve depends not only on the joint capacity of the condenser (i) and the valve (e) but chiefly on the temperature of the filament. The supply of electrons by the filament controls the current in the circuit. It is, therefore, sufficient to vary the current which heats the filament in order to obtain corresponding variations of the potential and current in the cell.

The characteristic curves shown in Figure 2 were obtained by the above method. The voltage at the direct current generator was maintained at 400 volts and the filament current varied by a sliding wire rheostat from 0.9 to 1.85 amperes.

The complete characteristic curve, observed over a range of 0-340 volts for currents from 0 to 4.5 milliamperes, consists of six distinct branches. To represent clearly the most interesting parts of the characteristic the graph is divided into three parts, and only the second and third parts are shown in Figure 2. The second part extending from 0.25 to 5 microamperes is drawn in a scale a thousand times larger than the third part including a range from 5 to 5000 microamperes. The first branch (a), not shown in the figure, is the part which follows an exponential low according to Townsend's theory

of ionization by collision. The second branch (b) culminates at a point P for a voltage of 334 volts which may be called the breakdown voltage. From this point on (0.9 microamp.) the branch is descending towards the point Q (310 v. and 56 microamp.). In this region an invisible radiation is probably emitted by the ionized gas molecules. The next branch (d) is rising towards the point R (325 v. and 135 microamp.) and is marked by a slight glow and violet irregular streamers starting at the anode and disappearing at a distance of about 1 cm. When the point R is reached a uniform bluish glow is uniformly filling the entire space of the side tube (c. Figure 1), the light becoming more and more intense as the current increases along the descending branch (e) towards the point S (245 volts and 400 microamp.). For the entire region of the characteristic until this point S is reached, the cell retains its photo-electric properties. At every point so far recorded by the graph the value of the current becomes zero, when the source of illumination (75 watt gas-filled tungsten lamp at a distance of 25 cm.) was screened off from the cell.

Shortly before the point S is reached, the current through the cell assumes small definite values even when the cell is not illuminated. These dark currents begin then to increase and in a very narrow region, in proximity of point S, become even larger than the current measured while the cell is illuminated. Thus a reversal of the photo-electric effect could be observed for which the action of illumination consisted in causing a decrease of current passing through the cell.

When the point S is passed pulsations in the intensity of the glow in the tube (c) set in, preceding the establishment of a regular striated blue discharge extending along the entire length of the cell. The rising branch (f) of the characteristic corresponds to this form of discharge, for which the illumination has no influence whatever. Evidently when the conditions are established corresponding to the lowest point on the branch (e), the discharge is transformed from a form dependent on the supply of photoelectrons by the sensitive layer of the cathode into an independent type of discharge, in which

sufficient ions are produced by successive ionization in the mass of the gas to sustain itself permanently.

The branch (e) of the characteristic curve corresponds to a luminous discharge which possesses a remarkable property of being photo-electrically controllable. If the illumination of the cell is screened off, the luminous discharge in the tube (c) disappears, reappearing immediately after the cell is again subjected to the source of light. Moreover, the intensity of the glow in the cell follows the variations of intensity produced by the illuminating source of light. Thus a phenomenon was experimentally demonstrated in which a source of light was photo-electrically excited and forced to vary following the variations of a distant source of light.

This method can be applied for stabilizing and for obtaining characteristics of other forms of discharges at atmospheric pressures and in rarified gases. The investigation is continued in this direction, and also the relation is studied between intensity of illumination and photo-electric current for every branch of the characteristic. Experiments are also conducted aiming to utilize the descending branches (c, e) of the characteristic for the production of electric oscillations.

A brief preliminary description of the arrangement was presented before the American Physical Society on December 30, 1924, and was published in the Phys. Rev., Vol. 25, February, 1925, p. 245.

This work was carried out in the laboratory of Professor Jacob Kunz, to whom acknowledgement is due for his encouragement and interest.*

* Preliminary note concerning this investigation was published in the Physical Review, Vol. 25, page 245, by J. T. Tykociner and J. Kunz.

SEPARATION AND DETERMINATION OF THE ALKALI METALS, USING PERCHLORIC ACID

I. THE SOLUBILITY OF THE PERCHLORATES OF THE ALKALI METALS IN MIXED ORGANIC SOLVENTS

G. Frederick Smith, University of Illinois

The quantitative separation and determination of the alkali metals is in general dependent upon the use of organic solvents. The most important separation in this group is that of potassium from sodium. The most common method involves the use of chloroplatinic acid and 80% ethyl alcohol but methods based on the use of perchloric acid have proved satisfactory in this as well as other separations of the alkali metals.[1] Improved methods of procedure in this group depend in part upon a thorough study of new organic solvents.[2] The present work is the first of a series of such studies.

The solubility of the perchlorates of the alkali metals in water and numerous organic solvents, including alcohols and ethyl acetate, has been determined.[2] The nature of the solubility effect obtained using mixed solvents constitutes a marked advantage over the use of individual solvents. The data reported in this paper include the solubility of anhydrous sodium, potassium, rubidium, cesium and ammonium perchlorates as well as sodium perchlorate monohydrate and lithium perchlorate trihydrate in mixtures of methyl, ethyl and N butyl alcohols in various proportions with ethyl acetate. The data are discussed in relation to their application to quantitative analysis.

INTRODUCTORY CONSIDERATIONS

Quantitative methods for separations in the alkali metal group consist of two types, precipitation and extraction processes. The separation of sodium and lithium by the method of Willard and Smith[1a] is of the former

1a. G. Frederick Smith, J. Am. Chem. Soc., *45*, 2072, (1923).
b. Baxter and Ropert, ibid., *42*, 2046, (1920).
c. Gooch and Blake, Am. J. Sci., *44*, 381, (1917).
d. Morris, Analyst, *45*, 349, (1920). Extensive bibliography.

2A list of organic solvents already studied in this connection includes N. butyl alcohol 1a, also Willard and Smith, J. Am. Chem. Soc., *44*, 2816 (1922); isobutyl alcohol, Winkler, Z. anal. Chem., *52*, 628 (1913); ethyl alcohol containing methyl alcohol 1b; ether and alcohol, Palkin, J. Am. Chem. Soc., 38, 2326, (1916); amyl alcohol, Gooch, Am. Chem. J., 9, 33 (1887); and pyridine, Kahlenberg and Krauskopf. J. Am. Chem. Soc., *30*, 1104, (1908).

type. The perchloric acid method for the separation of potassium and sodium is an extraction method. Sodium perchlorate would be more effectively separated from potassium perchlorate by extraction, using an organic solvent, if its solubility could be increased without increasing the solubility of the potassium salt. The selection of a mixture of solvents best suited to this end could be made only after an extended investigation, the results of which have been included in part in this paper.

PREPARATION OF MATERIALS

In a former paper[3] the opinion was expressed "that slight amounts of organic impurities, especially those similar in nature to the solvent used, would have no appreciable effect on the solubility results, but even traces of water have a large influence". An alcohol containing a small per cent of an isomeric alcohol or other member of its homologous series would fall under this classification of organic impurities. Such conditions would not hold for some mixtures of organic solvents such as esters contaminated with alcohols or alcohols with aldehydes.

The magnitude of the error resulting from the presence of a very small per cent of dissimilar organic impurity in a particular solvent is shown by the following example:

The solubility of anhydrous sodium perchlorate in a sample of ethyl acetate, physical constants of which duplicated the best values to be found in the literature,[5] was shown to be 8.80% at 25°. The same ethyl acetate containing 0.13% of its volume of anhydrous ethyl alcohol, dissolved 10.74%, an increase of over 22%. From this data it would seem probable that ethyl acetate containing as little as one part of ethyl alcohol in 20000 parts of ethyl acetate would dissolve anhydrous sodium perchlorate to the extent of one per cent in excess of the true value.

As a result of such considerations the solvents used for this work were those of a previous stock which had been carefully purified[5] or carefully selected and compared with the former. Solubility determinations were re-

[3] Willard and Smith, J. Am. Chem. Soc., 45, 286, (1923).
[5] Solvent 13 of reference 3.

peatedly made in establishing the purity of any given solvent. The identity of the samples of the same solvent was established if comparable solubility results were obtained. Solubility data for the pure solvents used are given in reference 3.

Ethyl Acetate. Solvent 13, Table 1, reference 3 was used in the case of all solubility determinations except those of potassium, rubidium and cesium perchlorates. These were determined, using a very pure anhydrous product obtainable in quantity from the usual sources. This material without further treatment was found to dissolve 9.11% of anhydrous sodium perchlorate at 25°. This corresponds to a purity of 99.98% assuming the only impurity to be ethyl alcohol.

Methyl Alcohol. An anhydrous material purchased in quantity from the usual sources was found to correspond with solvent number 2 of Table 1, reference 3. It was found to dissolve 6.42% of ammonium perchlorate and 34.33% of anhydrous sodium perchlorate as compared with 6.41% and 33.93% for the pure solvent. Technical methyl alcohol, dried over stick potassium hydroxide and distilled, dissolved 42.2% of anhydrous sodium perchlorate.

Ethyl Alcohol. 93% alcohol dehydrated with lime to 99.6% was made anhydrous by reaction with a slight excess of metallic calcium. Its boiling range was 78.29°-78.31° corrected, and its density was 0.78515 at 25°/4° corrected to vacuum. The undried alcohol used was found by density determination to be 93.1% in strength.

N Butyl Alcohol. The same as solvent number 10, Table 1 of Reference 3.

Perchloric Acid. Prepared as given in reference 1a.

Lithium, Sodium, Ammonium, Potassium, Rubidium and *Cesium Perchlorates.* The same materials described in reference 3. The latter three slightly soluble perchlorates were recrystallized from their solution in perchloric acid at the boiling point by cooling to 0° with the object of obtaining fine crystals which required no grinding before testing their solubility. The crystals thus obtained were known to have occluded a small amount of perchloric acid. This fact did not alter solu-

bility data in the organic solvents used, as in no case were the resulting solutions acid. This phenomenon of acid occlusion as exhibited by potassium, rubidium and cesium perchlorates is the subject of the second paper of this series.

Lithium Perchlorate Trihydrate. The same material used in reference 3.

Sodium Perchlorate Monohydrate. Prepared by crystallization of sodium perchlorate from water below 50°. The material thus obtained was drained centrifugally and dried at room temperature in contact with excess of anhydrous sodium perchlorate. Analysis of the product gave 12.87% water of crystallization as compared to a theoretical value of 12.82%.

APPARATUS AND METHODS

The experimental manipulations were carried out essentially as reported in reference 3, pages 290-293 inclusive. All determinations involving potassium, rubidium and cesium perchlorate were carried out, using from 80-100 cc. of the saturated solution in question with conversion of the dissolved perchlorates to sulfates as a means of determination. All determinations were made in duplicate and the strict concordance of the values obtained with those of previously reported determinations[3] is significant.

SOLUBILITY DATA

The solubilities in per cent by weight of anhydrous sodium perchlorate, hydrated sodium and lithium perchlorates and ammonium perchlorate in the various mixtures of solvents are listed in Table I.

TABLE I.

SOLUBILITIES OF SODIUM, LITHIUM AND AMMONIUM PERCHLORATES IN ETHYL ACETATE CONTAINING VARIOUS PROPORTIONS OF METHYL AND N-BUTYL ALCOHOLS AT 25° ± 0.1°

Vol.-% of alcohol		0	5	10	20	30	40
Vol.-%of ethyl acetate		100	95	90	80	70	60
Solute	Alcohol used						
$NaClO_4$	Methyl	8.80	.....	19.39	23.37	25.85	27.81
$NaClO_4$	Abs. Ethyl	8.80	13.83	16.05	18.55	19.66	20.08
$NaClO_4$	93% Ethyl	8.80	14.12	16.92	20.00	21.75	22.79
$NaClO_4$	N-Butyl	8.80	....	12.34	13.16	.....	12.82
$NaClO_4$	N-Butyl*	8.80	11.97	13.00	14.32	14.75	14.71
$NaClO_4H_2O$	Abs. Ethyl	26.32	.....	29.32	31.16	32.44	33.26
$LiClO_43H_2O$	Abs. Ethyl	26.35	.....	31.05	33.59	35.10	36.51
NH_4ClO_4	Methyl	0.029	.....	0.135	0.550	1.27	2.31

Vol. % of alcohol		50	60	70	80	90	95	100
Vol. % of ethyl acetate		50	40	30	20	10	5	0
Solute	Alcohol used							
$NaClO_4$	Methyl	29.38	30.50	31.61	32.56	33.44	.....	34.33
$NaClO_4$	Abs. Ethyl	20.07	19.67	18.78	17.53	15.82	14.80	12.83
$NaClO_4$	93% Ethyl	23.30	23.39	22.73	21.92	20.96	21.31	20.60
$NaClO_4$	N-Butyl	11.99	10.54	.....	6.70	4.35	.....	2.19
$NaClO_4$	N-Butyl*	13.98	13.09	11.66	9.85	7.87	6.97	4.27
$NaClO_4H_2O$	Abs. Ethyl	33.63	33.61	33.20	32.56	31.56	31.10	29.80
$LiClO_43H_2O$	Abs. Ethyl	37.96	38.58	39.79	40.84	41.77	.....	42.16
NH_4ClO_4	Methyl	3.47	4.35	5.08	5.67	6.12	.....	6.42

*The same alcohol reported in Ref. 1a; b. p., 112-118°; d_4^{25}, 0.8065.

The per cents by volume of the mixed solvents used for the solubilities of each vertical column are given in the first two horizontal rows. The solute used giving the data of each remaining horizontal row is given in the first vertical column. Likewise, the alcohol mixed with the ethyl acetate giving the solubilities contained in each horizontal row is listed in the second vertical column.

The data of Table 1 are represented graphically in Fig. 1, for the purpose of ready comparison.

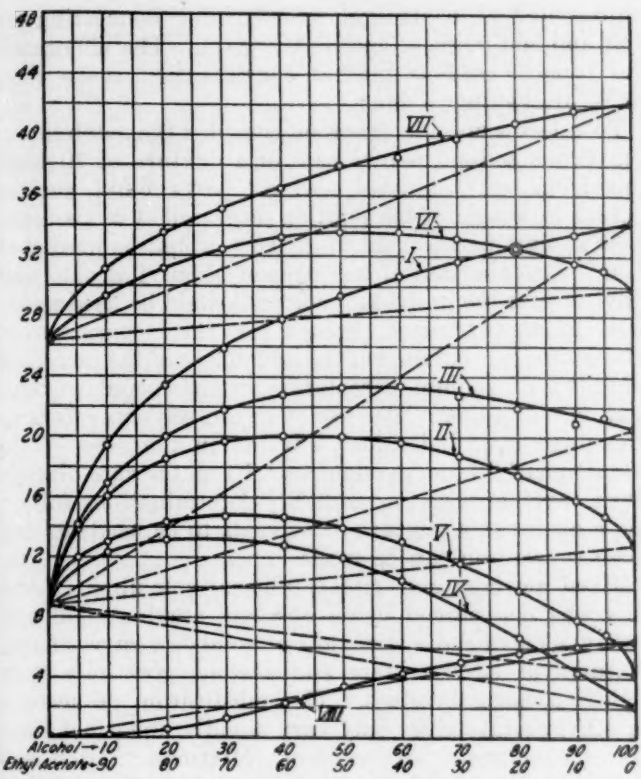


FIG. I.

The solubility in weight per cent of a given solute is plotted as ordinate. The mixed solvent proportions are plotted as abiscissa. The volume per cents of alcohol from 0 to 100 are plotted reading from left to right. Those of ethyl acetate are plotted on the same axis from 0 to 100 reading from right to left.

DISCUSSION.

From Table 1 and Fig. 1 it is obvious that the solubility of the anhydrous solutes determined are much higher in the mixed solvent than would be predicted from a knowledge of the solubility of the same solute in each individual solvent. Such a predicted series of solubilities would be

represented as a straight line function connecting the first and last point of each curve given. The abnormalities found based on such a consideration range from 100% or even more down.

To select a specific example, consider the solubility of anhydrous sodium perchlorate in a mixture of 20 parts anhydrous ethyl alcohol and 80 parts ethyl acetate. 18.55% by weight of the solution saturated at 25° is found to be sodium perchlorate while 9.6% would be predicted. In this case and that of mixtures of N butyl alcohol with ethyl acetate the individual solvents could be used as the basis of an extraction process for the separation of potassium and sodium, but the advantage of the increased solubility of sodium perchlorate in the mixed solvents is at once apparent. The use of mixed solvents offers no advantage over individual solvents in the case of the extraction of lithium perchlorate.[3] From the data already given, together with the solubility determinations following, a choice of a mixture of solvents to be used for any given separation can be made.

Mixed alcohols give rise to normal solubility effects. This was determined using absolute ethyl alcohol and N butyl alcohol and a straight line solubility curve found. Mixtures of ethyl acetate and acetone give only very slightly abnormal values. The substitution of acetone for ethyl acetate gives only very slightly abnormal solubilities when mixed with alcohols. Mixtures of ethyl acetate with alcohols are thus seen to be the most practicable to employ.

The abnormal solubility results just described could be obtained as a result of two plausible conditions, namely, interaction between the solvents of the mixture, or interaction between the anhydrous solute and one or both solvents. The former condition is indicated through the elimination of the latter as the result of experiment.

Lithium and sodium perchlorates form hydrates. If these solutes in their anhydrous form were dissolved in alcohols, it is possible "alcoholates" instead of hydrates might be formed. In such case the solubility of these modified solutes in alcohols and ethyl acetate might be greater than the anhydrous salts. The abnormal results obtained would thus be explained.

Accordingly the solubility of lithium perchlorate trihydrate in mixtures of ethyl alcohol and ethyl acetates was determined (Curve VII, Figure 1). Its solubility in both solvents is less than that of the anhydrous solute. Only slightly abnormal solubilities were obtained in the mixed solvents. Both circumstances fit the assumptions. With sodium perchlorate monohydrate, however, the solubility in the individual solvents is greater than that of the anhydrous salt and the abnormal solubilities less pronounced (Curve VI, Figure 1).

If the tendency to form "alcoholates" is associated with the formation of hydrates for a given solute, and the former condition gives rise to the abnormal solubility effects obtained in mixed solvents, normal results should be obtained using solutes for which hydrates are not known. The solubility of ammonium perchlorate, representing such an example, in mixtures of methyl alcohol and ethyl acetate was determined (Curve VIII, Figure 1). Here added abnormality was found. For small per cents of alcohol a marked depression of its solubility over the predicted value was obtained. Interaction of solute and solvent is probably therefore not an explanation for the results obtained.

THE SOLUBILITY OF POTASSIUM RUBIDIUM AND CESIUM PERCHLORATES IN MIXED ALCOHOLS AND ETHYL ACETATE.

As will be demonstrated in the subsequent papers of this series, the presence of free perchloric acid during the extraction of the soluble from the insoluble alkali perchlorates, using mixed solvents, is a pronounced disadvantage. The addition of perchloric acid for its common ion effect to mixed solvents containing ethyl acetate as the major constituent fails of its purpose. The solubilities considered in this section therefore omit the effect of small amounts of perchloric acid and are reported in Table II.

TABLE II.

The Solubility of Potassium Rubidium and Cesium Perchlorates in Mixed Alcohols and Ethyl Acetate at 25°

Vol. o/o Alcohol		10	15	20
Vol. o/o Ethyl Acetate		90	85	80
Solute	Alcohol used	g./100cc	g./100cc	g./100cc
$KClO_4$	Methyl	0.0035	0.0052	0.0055
	Ab Ethyl	0.0016	0.0026	0.0033
	93 o/o Ethyl	0.0028	0.0044	0.0050
	N Butyl	0.0024	0.0020	0.0025
$RbClO_4$	Methyl	0.0024		0.0043
	Ab Ethyl	0.0016		0.0010
	93 o/o Ethyl			0.0027
	N Butyl	0.0011		0.0013
$CsClO_4$	Methyl	0.0050		0.0056
	Ab Ethyl	0.0013		0.0023
	93 o/o Ethyl			0.0040
	N Butyl	0.0009		0.0012

The description of Table I already given serves likewise for Table II. The values reported in Table II cannot be considered of greater accuracy than approximately 0.5 milligram. All errors accumulating throughout the process of their determination tend to give high results. The data represent saturated solutions, a condition not obtained in practical applications. Predictions based upon the data given in Table II may be somewhat liberally interpretated.

The solubility of potassium perchlorate in pure ethyl acetate is 1.3 milligrams in 100 cc. at 25 (reference 3). Rubidium and cesium perchlorates are insoluble in ethyl acetate. Ethyl acetate should therefore be the wash solution in all cases. If one extraction was found sufficient, 20 cc. of extractant, representing one-fifth the solubilities given in Table II, would give the maximum error through solubility. Working at less than 25°, which is ordinary practice, would decrease this error. Any of the combinations of Table II could then be employed. If two extractions were found necessary, approximately 30 cc. of extractant would be required and the higher values of Table II would represent too great errors.

Absolute ethyl alcohol and ethyl acetate give the best values if the figures of Table I are also considered. 93%

ethyl alcohol can be substituted for absolute alcohol with but small decrease in accuracy. N butyl alcohol and ethyl acetate give the lowest solubilities and could probably be used in all proportions.

The data of the present paper are thus seen to be a practical guide to the selection of most probably favorable conditions for any of the separations involved. Exact choices depend upon a more thorough study of each case.

SUMMARY

1. The solubility of the alkali perchlorates in various mixtures of methyl, ethyl and N butyl alcohol with ethyl acetate have been determined.

2. The solubility data thus obtained were shown to represent conditions advantageous in the separation and determination of the alkali metals by the extraction process.

3. An attempt was made to interpret the abnormal solubility results and to point out their analytical significance.

4. Solubility determinations were shown to be of value in establishing the purity of the solvents employed.

Contribution from the
Chemical Laboratory
of
The University of Illinois

SEPARATION AND DETERMINATION OF THE ALKALI METALS USING PERCHLORIC ACID

II. THE PRECISE ESTIMATION OF THE INSOLUBLE ALKALI METAL PERCHLORATES

G. Frederick Smith and John F. Ross, University of Illinois

The separation of potassium rubidium and cesium from sodium and lithium by the perchloric acid method is dependent upon the extraction of the latter two perchlorates from the former, using an organic solvent. The choice of the most suitable solvent was the subject of the first paper of this series. The present paper has for its object the establishment of a correct procedure governing the

separation and weighing of the insoluble perchlorates of this group. The procedures previously described are shown to have appeared exact as the result of a fortuitous compensation of errors.

THE DEHYDRATION TEMPERATURE OF POTASSIUM PERCHLORATE

Four weighed samples of potassium chloride (a foreign stock guaranteed to be 100.00%) were dissolved in hot water in weighed platinum crucibles. One cc. of pure 72.5% perchloric acid was then added, the resulting solution evaporated to dryness and heated until the large excess of acid was completely removed. The potassium perchlorate thus obtained was dissolved by the addition of hot water and again precipitated by evaporation to dryness on the hot plate and baked two hours at approximately 140°. Crucible and contents were then dried three hours at 140-150°, cooled in a desiccator and weighed.

The samples were next dried one hour at 250° in a muffle, cooled as before and weighed. They were then dried 15 minutes at 350°, cooled and reweighed. Finally the samples thus treated were dried to constant weight at 350°. The results of the experiments are listed in Table I.

TABLE I.

The Dehydration at Various Temperatures of Potassium Perchlorate Crystallized from its Solution in Water.

	KClO$_4$ Found					
KCl taken	3 hrs. 140-150°	1 hr. 250°	15 min. 350°	Constant Wt. 350°	Theoretical KClO$_4$	Error KCl
g	g	g	g	g	g	g
0.15555	0.28965	0.28945	0.28915	0.28915	0.28905	+0.00005
0.11580	0.21585	0.21555	0.21530	0.21530	0.21520	+0.00005
0.11645	0.21700	0.21685	0.21650	0.21650	0.21640	+0.00005
0.15925	0.29670	0.29660	0.29620	0.29620	0.29595	+0.00015

The potassium chloride used for the determinations of Table I had been previously ground and ignited several hours at 500°. The samples were weighed from a very small weighing bottle directly into the platinum crucibles previously cleaned and ignited. All weighings were made using a number 10 Troemner balance and weights calibrated at the Bureau of Standards. The conversion factor of potassium perchlorate to potassium chloride

was taken as 0.53810. The perchloric acid used had been purified by distillation under reduced pressure from an all glass pyrex distillation apparatus and was shown to be free from nonvolatil products.

The experiments listed in Table I show that potassium perchlorate crystallized from its solution in water can be quantitatively freed from the last traces of occluded moisture at a temperature of 350°. Samples of potassium perchlorate dried at 150° may contain approximately 0.3% of their weight of occluded moisture. Half of this is removed by treatment at 250°. The potassium perchlorate prepared for the experiments of Table I after treatment at 350° was tested for chloride formed by decomposition but no trace was found. Essentially the same results were obtained using cesium chloride, the magnitude of the error in this case being considerably less.

Descriptions, in general, of procedures for the separation and determination of K by the perchlorate process call for the drying of the potassium perchlorate at 150°. One procedure requires that 200° be employed.[1] The error thus introduced in the best work, following the usual procedure, is in general very satisfactorily compensated for by the solubility of potassium perchlorate in the organic solvent used in its separation.

THE OCCLUSION OF PERCHLORIC ACID BY THE INSOLUBLE ALKALI PERCHLORATES

The conversion of potassium, rubidium and cesium chlorides to perchlorates previous to their separation from sodium and lithium requires the evaporation of their solution in water with excess of perchloric acid. This evaporation results in the concentration of the excess perchloric acid to approximately the constant boiling aqueous acid of 72.5% strength. Potassium, rubidium and cesium perchlorates are freely soluble in hot 72.5% perchloric acid. The conversion of the chlorides of these metals to perchlorates followed by the evaporation of most of the perchloric acid is therefore, to considerable extent, a crystallization process in which strong per-

[1] Baxter and Kobayashi, J. Am. Chem. Soc., 39, 249, (1917).

chloric acid is solvent. The present section deals with the occlusion of perchloric acid during this operation.

The solubilities of potassium, rubidium and cesium perchlorates in 72.5% perchloric acid at the boiling point are approximately 125 mg., 250 mg. and 1 g. in 1 cc. respectively. Their solubilities in the same acid at 25° are 3.7, 8.9 and 81.5 mg. per cc. respectively.

Potassium, rubidium and cesium perchlorates prepared as given by Willard and Smith[2] were dissolved in hot 72.5% perchloric acid and precipitated by rapid cooling to 0°. The crystals thus obtained were filtered centrifugally and washed twice with cold water using centrifugal drainage. The samples thus obtained were tested without further treatment, then after drying two hours at 120°, two hours at 250° and lastly 30 minutes at 350°, samples of approximately 0.5 gram each were dissolved in water and titrated with fiftieth normal sodium hydroxide solution, using methyl red as indicator. The results were as follows:

Treatment of Material	Per cent $HClO_4$			Chloride Test
	$CsClO_4$	$RbClO_4$	$KClO_4$	
2 hrs.—120°	0.16	0.85	1.4	
2 hrs.—250°	0.14	0.75	1.1	Positive
½ hr. —350°	0.04	0.08	0.25	Positive

The occlusion of perchloric acid by the three perchlorates crystallized from hot 72.5% perchloric acid is thus seen to be greatest for potassium and least for cesium perchlorate. The occlusion is greatest for the perchlorate least soluble in the strong acid and least for the most soluble one. The occluded acid is not completely removed at 350° during thirty minutes heating. In all these cases the removal of perchloric acid at the higher temperatures was accompanied by a well defined decomposition with formation of chloride not obtained by heating the acid free perchlorate at the same temperature.

The nature of this occlusion of perchloric acid is easily observed upon examination of the crystals thus prepared, with the microscope, magnifying about 100 diameters. Figures 1 and 2 are micro-photographs of potassium perchlorate prepared as described, the former examined as prepared and the latter after drying at 350°.

[2]Willard and Smith, J. Am. Chem. Soc., 45, 286 (1923).

Fig. I.

Fig. II.

From the examination of Figure I it is observed that potassium perchlorate crystallized from its solution in strong perchloric acid is obtained as long, hollow, tubular crystals in the hollow portion of which the mother liquor is frequently enclosed. Several darkened central portions of the crystals photographed indicate mother liquor enclosures. A peculiar phenomenon is the apparently convex rather than concave terminations of the liquid contained in the capillaries.

The crystals shown in Figure 2 are a separate portion of the same material dried at 350°, and are seen to have a very extensively pitted and cratered structure caused by the evolution of gaseous products accompanying the elimination of their acid impurity as well as by their own partial decomposition. Since sodium perchlorate is readily soluble in strong perchloric acid, its presence during the crystallization of potassium perchlorate would result in the occlusion of an appreciable amount of the former as a result of the occlusion of its acid solution.

The extraction process as applied to the separation of potassium and sodium, using any of the previously described organic solvents,[1] results in the separation of potassium perchlorate containing occluded perchloric acid, since the tendency towards acid occlusion is dependent upon the preliminary treatment with excess perchloric acid which is concentrated during the requisite elimination of the more volatil acids. The extent of this acid occlusion is never as pronounced in actual practice as in the analyses given since the insoluble perchlorates are not formed under the same extreme conditions.

That the occlusion of acid cannot be dependent upon the nature of the organic solvent used in the extraction was demonstrated under actual working conditions. Three 250 milligram samples of potassium chloride were dissolved in water and converted to perchlorate with excess perchloric acid and all but a small portion of the acid evaporated on the hot plate. The barely moist residue of potassium perchlorate was then partially cooled and treated with extracting solvent. Twenty-five cc. portions of absolute ethyl and N butyl alcohols and ethyl acetate were used, and the potassium perchlorate in each case filtered into platinum sponge crucibles and thoroughly

washed with additional solvent. The samples thus obtained were dried one hour at 140-150°, dissolved in water and tested for acid. All contained appreciable amounts of free acid, approximately 0.5 milligram as estimated by titration with fiftieth normal sodium hydroxide.

THE RELATION TO PREVIOUS WORK OF OCCLUSION OF ACID AND MOISTURE

Willard,[3] who was the first to suggest the use of ethyl acetate in an extraction method for separating potassium and sodium, showed that potassium perchlorate obtained by the usual method of analysis occludes perchloric acid. The effect of the errors of occlusion giving high results are counterbalanced by the appreciable solubility of potassium perchlorate in the solvents usually employed in its separation. The low solubility of potassium perchlorate in ethyl acetate,[3] minimizing the latter of these two effects, appears to augment the former.

The most complete work on the perchlorate method is that of Morris,[4] which contains an extensive bibliography covering the principles and their application as well as a large number of tabulated determinations under a wide variation of conditions. This work contains the best details and procedures. Morris uses the methods described by Caspari[5] and by Gooch and Blake[6] with some slight modifications, and states that "given attention to essential details, results approach to scientific accuracy." In view of the errors of occlusion already demonstrated in connection with this paper a considerable number of the determinations of Morris appeared exact only as a result of a compensation of errors.

The description of the process followed by Morris[4] is here quoted to facilitate discussion:

"In nearly all cases the solution of the salt was evaporated with perchloric acid, three times in all, and the

[3]H. H. Willard. "Advanced Quantitative Analysis." 5th Ed. 1920. (Mimeographed by C. C. Edwards, Ypsilanti, Michigan.) Page 106, "At 24°, 100 cc. of pure ethyl acetate dissolves 1.1 mg. of potassium perchlorate; at 0°, 0.9 mg. while the solubility of sodium perchlorate is about the same as in absolute ethyl alcohol. The only difficulty attending its use is that occasionally the potassium perchlorate contains free perchloric acid or some organic compound with an acid reaction, which is not removed by drying at 150°."

[4]Morris, Analyst, 45, 349 (1920).

[5]Caspari, Z. angew. Chem., 6, 68, (1893).

[6]Gooch and Blake, Am. J. Sci., 44, 381, (1917).

final evaporation taken practically to dryness. The residue was treated with 10 cc. of wash liquid, stirred well with a flat headed glass rod, allowed to stand ten or fifteen minutes when sodium was present, occasionally stirring; the solution decanted through a weighed Gooch crucible containing asbestos. When only potassium was present, the precipitate was then rinsed out directly with the wash liquid in measured quantity by means of a wash bottle. When sodium was present the basin containing the residue from the first decantation was placed on the top of the air oven for a few minutes, till the alcohol was evaporated; then the residue was dissolved in the minimum amount of boiling water, and again evaporated to dryness. The treatment with 10 cc. of wash liquid and decantation was repeated and the residue then transferred completely by using the latter 10 cc. of the filtrate. Finally a measured volume of the wash liquid was added (by the use of a small pipet) in portions, to complete the washing on the filter. The Gooch crucible and contents were then dried for about an hour at 130° to 150° C., cooled for one hour in a desiccator and weighed. After weighing, 2 or 3 cc. more wash liquid were passed through the filter, and the drying and weighing repeated. The weight was taken as constant when, on washing with 2 or 3 cc. of liquid, the difference on successive weighings did not vary by more than one or two tenths of a mg."

According to this procedure if potassium perchlorate alone is present its determination is accompanied by an acid as well as moisture occlusion neither of which are eliminated at 150°. These errors are satisfactorily counterbalanced by the solvent action of the alcohol.[7] If sodium is present the procedure calls for a double extraction with intermediate evaporation of the potassium perchlorate. This eliminates the acid occlusion error but not that of the occlusion of moisture. The contamination

[7]Compare the values obtained in Table I of reference 4. A total of 2.3774 grams of potassium chloride taken for 21 analyses resulted in the recovery of 4.4177 grams of potassium perchlorate corresponding to 2.3773 grams of potassium chloride. 664 cc. of filtrate and washings were accumulated in the 21 analyses. Analysis 7 is illustrative of the failure of the solvent action to compensate for the errors of occlusion in the large sample used. 0.6685 grams of potassium chloride were recovered from 0.6673 grams taken for analysis. It cannot be agreed (page 365, reference 4) that "it is obvious that the mere stirring up of pure potassium perchlorate with the wash liquid and decantation (twice with 10 cc. each time) causes no appreciable loss, so that the loss by continued washing of the precipitate on the asbestos is the chief cause of low results."

of potassium perchlorate by the sodium salt, even after double extraction, more than equals the acid occlusion error which has been eliminated.[8] This condition is unavoidable using ethyl alcohol as extracting solvent. By the use of mixed solvents,[9] which have much greater solvent action on sodium perchlorate, the sodium occlusion error can be appreciably diminished. The washing of a dried and weighed sample of potassium perchlorate with additional solvent, followed by a second drying and weighing to test the complete removal of sodium which might have remained from previous washing as a result of a restricted use of wash alcohol, is a very unsatisfactory portion of the procedure.

Some procedures[10] for the separation of potassium and sodium provide for the resolution in a dilute solution of perchloric acid of the potassium perchlorate, following its original formation in the same acid and first extraction. The potassium perchlorate is then precipitated by evaporation nearly to dryness. Obviously this practice does not eliminate acid occlusion.

IMPROVED PROCESS FOR THE SEPARATION BY EXTRACTION OF THE ALKALI PERCHLORATES

As a result of the experiments of the first two papers of this series the following procedure for the separation of the alkali perchlorates by extraction is proposed:

The mixed chlorides obtained by the J. Lawrence Smith or other method, free from ammonium salts, are dissolved in water and treated with two or three times the equivalent quantity of pure perchloric acid (not less than 1 cc. of 60-70% acid) and the solution thus obtained evaporated to dryness on the hot plate in a 150cc. pyrex beaker. The beaker and contents should be dry and any acid condensed on the side walls of the beaker should be removed by brushing with a free flame. The beaker is then cooled appreciably and the contents dissolved by the addition of a minimum of hot water (2 or 3 cc. generally suffice) and the solution again evaporated to dryness on the hot plate.

[8]Table II. Reference 4, page 358.
[9]Compare the values given in the first paper of this series. J. Am. Chem. Soc., 47, 762, (1925).
[10]Baxter and Rupert, J. Am. Chem. Soc., 42, 2046, (1920).

10-20 cc. of the mixed organic solvent selected for the extraction is now added to the sufficiently cooled beaker and the solution digested near the boiling point 2 or 3 minutes. The solution is cooled to room temperature and the supernatant liquid decanted through a previously ignited and weighted platinum sponge crucible and washed three times by decantation to remove most of the soluble perchlorate extracted, and the residue dissolved in the minimum of hot water and again evaporated to dryness.

The salts are extracted the second time as before, using 10 cc. of solvent, digested, cooled and filtered into the original crucible. The precipitate is transferred to the crucible, using a fine jet from a wash bottle containing the same solvent, and the crucible contents washed with 10-15 portions of ½-1 cc. from the wash bottle. The filtrate is concentrated on the hot plate to the proper volume preparatory to its subsequent analysis. The precipitating beaker is returned to the hot plate until dry and any unremoved particles of perchlorate thus formed brushed in with the bulk of precipitates.

The crucible and precipitate are dried a few minutes at 100° in an oven and finally 15 minutes in a muffle at 350°, cooled and weighed. The filtrate and washings by this process should range from 35 to 45 cc. If no sodium or lithium perchlorate is present the second precipitation and extraction can be omitted.

Gooch and Blake[11] have found that perchlorate acid has a decided action on glass which may result in the contamination of the perchlorates determined by silica. The study in connection with the perchloric acid process reported in this series of papers has shown no appreciable action on pyrex beakers. Platinum sponge filtering crucibles have in most cases been weighed subsequent to their use in filtering potassium perchlorate obtained by evaporation of perchloric acid in excess, and no increase in weight due to silica has been found. Any silicic acid resulting from the action of the acid on the beakers would have been dehydrated during the evaporation process.

It will be noted that the improved procedure given above does not involve the use of any organic solutions

[11]Gooch and Blake, Am. J. Sci., 44, 381, (1917).

containing perchloric acid. Any remote danger of violent reaction resulting from the use of such solutions is eliminated.

SUMMARY.

1. The correct drying temperature of the insoluble alkali perchlorates has been determined.
2. The occlusion of perchloric acid by these salts has been studied.
3. Previous procedures for the perchloric acid separation of the alkali metals by extraction were shown to be faulty and an improved method is described.

Contribution from the
Chemical Laboratory
of
The University of Illinois

THE SEPARATION AND DETERMINATION OF THE ALKALI METALS USING PERCHLORIC ACID.

III. NORMAL BUTYL ALCOHOL AND ETHYL ACETATE AS MIXED SOLVENTS IN THE SEPARATION AND DETERMINATION OF POTASSIUM, SODIUM AND LITHIUM

G. FREDERICK SMITH AND JOHN F. ROSS,
UNIVERSITY OF ILLINOIS

N butyl alcohol and ethyl acetate as mixed solvents have been selected as one of the various combinations of organic solvents with properties best suited to the separation of the soluble from the insoluble alkali metal perchlorates by the extraction process.[1] N butyl alcohol has been used as solvent in the separation and determination of sodium and lithium by a process involving the precipitation and gravimetric determination of sodium as the chloride followed by the estimation of lithium by conversion to sulfate.[2] N butyl alcohol is not entirely satisfactory as extracting solvent to be used in the separation of sodium and lithium from potassium perchlorate because of the low solubility of sodium perchlorate. By the use of the mixed solvents given above this objection is eliminated. The demonstration of imperfections in pre-

[1]G. Frederick Smith, J. Am. Chem. Soc., 47, 762, (1925).
[2]Willard and Smith, J. Am. Chem. Soc., 44, 2816, 1922.

viously described methods and the development of an improved procedure for the extraction separation of the alkali metal perchlorates was the object of the second paper of this series.[3] The present paper applies the principles established in references 1, 2 and 3 to the quantative separation and determination of potassium sodium and lithium including the volumetric estimation of sodium using standard silver nitrate (Mohr's method).

THE METHOD

The process, in brief, is as follows:

The mixture of potassium, sodium and lithium chlorides are converted to perchlorates by evaporation of their solution with excess of pure perchloric acid, the latter removed by evaporation to dryness twice with intermediate solution in water. Sodium and lithium perchlorates are extracted, using a mixture of equal parts N butyl alcohol and ethyl acetate. The potassium perchlorate thus obtained after decantation, using a weighed Gooch crucible, is washed twice by decantation dissolved in water and the process repeated. The purified potassium perchlorate is filtered, using the same Gooch crucible, washed with the extracting solvents, dried at 350°, cooled and weighed.

The combined filtrate and washings totaling 50-70 cc. are evaporated on the hot plate until the ethyl acetate is removed and the sodium and lithium perchlorates in N butyl alcohol solution separated by the addition of a butyl alcohol solution of hydrogen chloride according to the reaction.

$$NaClO_4 + HCl \rightarrow NaCl + HClO_4$$

The reagent is added to the solution of the perchlorates until a 6% acid concentration is obtained. The precipitated sodium chloride is filtered, using a Gooch crucible, washed with a 6% solution of hydrogen chloride in butyl alcohol, dried at 110-125° and finally ignited a few minutes at a barely visible red heat. The sodium chloride thus obtained is dissolved in water and titrated with standard silver nitrate using potassium chromate as indicator (Mohr's method).

[3] G. Frederick Smith and J. F. Ross, J. Am. Chem. Soc. 47, 774, (1925).

The filtrate from the sodium determination is diluted with 10 cc. of water, evaporated to remove organic matter and the lithium salt thus obtained converted to lithium sulfate in the usual manner.

PREPARATION OF MATERIALS

Normal Butyl Alcohol.—This material is readily obtainable on the market at the present time at a moderate price. The alcohol used in this research had a boiling range of 112-118° and a density of 0.8065 at 25°/4°; 60 o/o of this product boiled within a range of 1° of the true boiling point. This fraction, when dried by refluzing with a slight excess of metallic calcium had a boiling range of 116.2-116.7° and a density of 0.8060 at 25°/4°. Half of this fraction boiled within a range of 0.05°. In most of the work the 60 o/o fraction, obtained as described above, was used.

Perchloric Acid.—The method of Willard[4] was used for the preparation of the perchloric acid. It was twice distilled under a pressure of from 5 to 15 mm. and contained about 72 o/o $HClO_4$. Ten g. of this material when evaporated in a platinum crucible gave an almost unweighable residue after ignition.

Sodium Chloride.—An imported product of highest purity was used.

Potassium Chloride.—The same stock and quality of product as the sodium chloride.

Lithium Perchlorate.—The method employed in the preparation of this material was that described by Richards and Willard.[5] Lithium nitrate was purified by recrystalization and then precipitated by the addition of hydrofluoric acid. The lithium fluoride was converted to perchlorate by evaporation with pure perchloric acid. This was then recrystalized from water with centrifugal drainage, platinum vessels being used throughout. The lithium perchlorate trihydrate thus obtained was dehydrated by fusion in a current of dry air at 250°.

The Solution of Hydrogen Chloride in Butyl Alcohol.—Butyl alcohol was treated with hydrogen chloride generated in the usual way by the action of concentrated sul-

[4]Willard, J. Am. Chem. Soc., 34, 1480, (1912).
[5]Richards and Willard, J. Am. Chem. Soc., 32, 4 (1910).

furic acid on sodium chloride or concentrated hydrochloric acid; 200 cc. of 20 o/o solution could be prepared in 2 or 3 hours.

Ethyl Acetate.—The same as that tested for use in connection with reference 1. It is very easily prepared in an equal state of purity and with excellent yields from cheap technical products.

APPARATUS AND EQUIPMENT.

Hot perchloric acid is said to have a solvent action on some types of laboratory glass and porcelain ware resulting in contaminations with silica. Pyrex glass is not thus affected and should be used for all evaporations involving perchloric acid. Gooch crucibles using asbestos have been found adequate for all filtrations involved in this work, but are far less convenient than platinum sponge crucibles. The advantage of the latter is most pronounced wherein the substances filtered are water soluble and the solutions organic in nature.

Means should be provided for filtration under reduced pressure from beaker to beaker without transfer. Evaporations of solutions containing perchloric acid are best conducted on an electric hot plate providing a sufficient temperature to fume it. In addition to the usual laboratory oven an electric muffle is desirable for ignitions at 350° and 500-600°. A ring burner is essential for conversions of lithium perchlorate to lithium sulfate.

PROCEDURE

The mixed chlorides of potassium, sodium and lithium obtained by the J. Lawrence Smith or other method, free from ammonium salts, are dissolved in water and treated with two or three times the equivalent quantity of pure perchloric acid (not less than 1 cc. of 60-70 o/o acid) and the solution thus obtained evaporated to dryness on the hot plate in a 150 cc. pyrex beaker. The beaker and contents should be dry and any acid condensed on the side walls of the beaker should be removed by brushing with a free flame. The beaker is then cooled appreciably and the contents dissolved by the addition of a minimum of hot water (2 or 3 cc. generally suffice) and the solution again evaporated to dryness on the hot plate.

10-20 cc. of a mixture of equal parts by volume of N butyl alcohol and ethyl acetate is now added to the sufficiently cooled beaker and the solution digested near the boiling point 2 or 3 minutes. The solution is cooled to room temperature and the supernatant liquid decanted through a previously ignited and weighed platinum sponge crucible and washed three times by decantation to remove most of the soluble perchlorates extracted, the residue dissolved in the minimum of hot water and again evaporated to dryness.

The salts are extracted the second time as before, using 10 cc. of solvent, digested, cooled and filtered into the original crucible. The precipitate is transferred to the crucible, using a fine jet from a wash bottle containing the same solvents used for the extraction and the crucible contents washed with 10-15 portions of ½ to 1 cc. from the wash bottle. The filtrate is started concentrating on the hot plate at this point. Any unremoved particles of perchlorate found in the original beaker after drying on the hot plate are brushed in with the bulk of precipitate. The crucible and precipitate are dried a few minutes at 110° in an oven and finally 15 minutes in a muffle at 350°, cooled and weighed. The filtrate and washings by this process should approximate 50 cc. If sodium is absent lithium can be completely separated from potassium by one extraction.

The filtrate from the potassium determination is evaporated on the hot plate until the ethyl acetate is dispelled, which is accomplished by concentrating to 40 o/o of the original volume and the hot solution of sodium and lithium perchlorates in N butyl alcohol 20 cc. in volume is treated with 8 cc. of 20 o/o hydrochloric acid butyl alcohol solution, adding the first cc. dropwise with constant stirring. After cooling to room temperature the sodium chloride precipitate is filtered on a platinum sponge crucible and washed 8 or 10 times with a 6-7 o/o solution of hydrogen chloride in butyl alcohol (made by diluting 100 cc. of alcohol with 40 cc. of 20 o/o hydrochloric acid-butyl alcohol solution). The crucible and precipitate are dried a few minutes in an oven at 110° and finally ignited for 5 minutes at 600° in a muffle (a free flame may be used but a very dull red must not be exceeded). The sodium

chloride precipitate is dissolved in the cooled crucible, using a fine stream of water from the wash bottle, and the crucible thoroughly washed in the same manner, receiving the filtrate in a 150 cc. beaker. The precipitate of sodium chloride will be gray because of occluded carbon, and the dissolved sodium chloride will leave a carbonaceous residue in the crucible. If it is desired to determine sodium gravimetrically the dried and ignited crucible should be weighed prior to removal of its sodium chloride content and again after the solution of sodium chloride in water and drying of the crucible and insoluble residue at 110° for one hour. The loss in weight is pure sodium chloride. By the volumetric procedure the sodium chloride solution is diluted if necessary to 50 cc. and titrated, using standard N/10 silver nitrate and 1 cc. of a 5 o/o solution of potassium chromate free from chloride as indicator (Mohr's method). The silver nitrate is best standardized using pure sodium chloride and a correction should be applied for the solution required to produce the end point reaction. The result by both the gravimetric and volumetric procedure agree.

The filtrate and washings from the sodium chloride are diluted with 1/3 their volume of water (to avoid subsequent deflagration), forming 2 layers, and the whole is evaporated on the steam-bath in such a way as to avoid any condensation on the upper part of the beaker. It is well to add 5 to 10 cc. of water at the end to make the removal of organic matter more complete before the perchloric acid fumes appear. If a slight brown coloration is present, remove the watch glass supports from the beaker and heat the covered beaker on a wire gauze to fumes of perchloric acid. If any brown color remains adhering to the beaker walls after this treatment it can be removed by brushing the walls of the beaker with the flame. If not enough perchloric acid is present to oxidize the last traces of organic matter, a few drops are to be added. When the brown coloration is removed, 0.5 cc. of concentrated sulfuric acid is added, the watch glass replaced and the acid fumed off, using either a hot plate or low flame and wire gauze. The beaker is then cooled, 5 to 10 cc. of water is added, and the cover glass

and beaker walls washed. The lithium sulfate is then transferred to a platinum crucible previously ignited and weighed with its lid. The solution is cautiously evaporated to dryness and the covered crucible is heated, preferably by a ring burner, until every trace of acid is removed, after which it is heated to 600° in a muffle for 5 to 10 minutes. When the same treatment is carried out using a free flame and a very dull red heat, some reduction to sulfide often takes place, due to diffusion of the flame gases through the platinum. Fusing with a free flame to check the weight obtained by the above treatment is possible if the temperature is not too high or the treatment too long.

The test analyses of various mixtures of pure potassium and sodium chlorides and lithium perchlorate are reported in Table I.

TABLE I.

SEPARATION OF POTASSIUM, SODIUM AND LITHIUM WITH DETERMINATION OF POTASSIUM AND SODIUM

	KCl taken G.	NaCl taken G.	$LiClO_4$ taken G.	KCl found G. 1 extr.	KCl found G. 2 extr.	NaCl found G. Grav.	NaCl found G. Vol.	Error* NaCl Mg.	Error† KCl Mg.	Determination of K
1	0.12925	0.1306	.....	0.1305	0.1292	0.1306	0.1307	+0.1	—0.05	60
2	.14625	.1349	.....	.1472	.1462	.1344	.1345	— .4	— .05	50
3	.16105	.13585	.....	.1624	.1608	.....	.....‡	— .25	— .25	55
4	.1416	.13545	.....	.14265	.1416	.13495	.1352	— .25	∓ .0	50
5	.1310	.1352	.....	.1323	.1311	.13465	.1343	— .9	+ .1	56
6	.2346	.03175	.....	.....	.2336	.....	.0316	— .15	—1.0	75
7	.05275	.1944	.....	.....	.0528	.....	.1934	—1.0	+ .05	75
8	.10555	.0889	.....	.....	.1052	.....	.0886	— .3	+ .05	60
9	.0851	.11985	.....	.....	.0847	.....	.1194	— .45	— .4	61
10	.10385	.....	.....	.1036	.....	.....	.....	.....	— .25	45
11	.13315	.....	.....	.1329	.....	.....	.....	.....	— .25	45
12	.10385	.....	0.2045	.1039	.....	.....	.....	.....	— .05	63
13	.1802	.....	.20135	.1801	.....	.....	.....	.....	— .1	50
14	.11015	.....	.24665	.1103	.....	.....	.....	.....	+ .15	51
15	.2108	.....	.56045	.2108	.....	.....	.....	.....	∓ .0	59
16	.12045	.....	.1984	.1205	.....	.....	.....	.....	∓ .05	58

*Based on two extractions if made.
†Based on volumetric sodium determination.
‡Sodium determination lost by "running through" and was discarded.

DISCUSSION OF RESULTS

It will be seen upon examination of the results of Table I that two extractions are necessary for the satisfactory separation of potassium and sodium (analyses 1-5 inclusive). The results obtained are considerably better for both a single and double extraction using the mixture of equal parts N butyl alcohol and ethyl acetate than are obtained by the use of absolute ethyl alcohol.[6]

[6]Compare with the results obtained by Baxter and Kobayashi, J. Am. Chem. Soc., 39, 249, (1917).

A single extraction gives excellent results for the separation of potassium and lithium (analyses 12-16 inclusive) even though samples larger than ordinarily separated are taken (analysis 15). In all the separations, although results for potassium are very close to the truth, this can result only from a very slight occlusion of the material extracted partially substituting for the potassium perchlorate dissolved.

The solubility of potassium perchlorate in the mixture of equal parts of N butyl alcohol and ethyl acetate under actual working conditions at room temperature is seen to be 1.0 mg. in 100 cc. corresponding to 0.6 mg. of potassium chloride or 0.34 mg. of potassium oxide. (Analyses 10 and 11.)

The results for the sodium determination are somewhat low, 0.9677 grams of sodium chloride being recovered from 0.9710 grams taken for eight analyses, an average loss of 0.4 mgs. per determination. Volumetric and gravimetric sodium chloride determinations agree satisfactorily, and by either method are much more rapid than the usual sodium sulfate estimation. The sodium chloride precipitation can be made more complete than that of Table I by using ethyl acetate alone as wash liquid during filtration of potassium perchlorate, which results in the presence of less butyl alcohol during precipitation with hydrogen chloride.

The average filtrate and washings for the potassium determinations of Table I was 58 cc., and 51 cc. for the sodium determination. No attempt was made to restrict the use of solvent either in the extraction or filtration and washing of the precipitates dealt with in Table I beyond amounts needed in ordinary manipulation. The use of a solubility correction for the sodium determinations of Table I was not applied as was justified by the work of reference 2. The latter reference should be consulted for a more thorough discussion of all the points involved in the separation and determination of sodium and lithium and for test analyses in the same separation. For this reason the determinations of lithium in Table I were omitted.

The analyses of Table I were consecutive results with no omissions. The reliability of the process is thus

demonstrated. No violent reactions were encountered throughout this work.

SUMMARY

The use of a mixture of equal parts N butyl alcohol and ethyl acetate has been shown by test analyses to be satisfactory for:

1. The extraction separation of potassium and sodium perchlorates, two extractions with intermediate solution of potassium perchlorate being required.
2. The extraction separation of potassium and lithium perchlorates, one extraction only being required.
3. The separation of sodium and lithium subsequent to their extraction from potassium following the procedure of Willard and Smith in which sodium chloride is precipitated from solution in N butyl alcohol, by a hydrogen chloride solution in the same solvent. The sodium was determined volumetrically by Mohr's method.

Contribution from the
Chemical Laboratory
of
The University of Illinois

TARTARIC ACID FROM COAL TAR BENZENE

ETHEL M. TERRY, UNIVERSITY OF CHICAGO

During the hundred years which have elapsed since Wöhler's discovery of the synthesis of urea, one of the important duties of the chemist has been the preparation of naturally occurring substances by artificial means in order to furnish for our use a more abundant and often a purer product than nature provides. As is well known, many of these so called syntheses have become of great importance.

Tartaric acid is at present supplied as a by-product of wine making. The salts of tartaric acid occur in the juice of grapes to the extent of 0.3 to 1.7%. As the grapes ferment and the alcohol content of the juice rises, the potassium acid tartrate along with some calcium tartrate is precipitated. These salts are collected and are the source of free tartaric acid or its salts as at present furnished to industry. Their most important use at present is in the preparation of textiles for the reception of dyes.

It is the purpose of this paper to describe how tartaric acid may be prepared efficiently from the coal tar benzene, a cheap and abundant material.

The first stage is the process of Weiss and Downs, announced in 1920, for the oxidation of benzene to maleic anhydride. The oxidizing agent is air and the catalyst or oxygen carrier is an oxide of the rare element vanadium (V_2O_5). The process is a flameless combustion of benzene on the surface on the catalyst at about 400° C. Sixty percent of the heat of the entire combustion of benzene is liberated and must be conducted away. If the temperature rises, combustion of maleic anhydride, the desired product, occurs and the net yield is carbon dioxide and water. We may well admire the control of Messrs. Weiss and Downs of this "hair trigger" reaction. Their catalyst can be used repeatedly. The two other ingredients, benzene and air, are available at a low price.

The second stage in the preparation of tartaric acid from benzene has been more recently completed and it is to this part of the process that detailed attention is called.

Maleic anhydride may be dissolved in water to form maleic acid. If this acid is heated or exposed to light in the presence of a suitable catalyst, the atoms attached to the two inner carbon atoms rearrange themselves and fumaric acid results. Either maleic acid or fumeric acid can be oxidized in water solution to tartaric acid.

One of our cheapest oxidizing agents is sodium chlorate. In water solution it is rather inert, but in the present instance it acts effectively provided a small amount of osmium tetroxide is furnished as "go between" or oxygen carrier from chlorate to maleic or fumaric acid.

In 1913, Holman, Ehrhart and Schneider, in exploring the reactions of water solution of osmium tetroxide and various chlorates with a variety of substances, found that reagent would oxidize the acid salts of either fumaric or maleic acid to form tartrates. At the time of this discovery maleic acid was made from the very expensive malic acid of apples and was known only in the research laboratory so that the reaction was of little general interest. According to the Holfmann method upwards of 40 percent of the initial material was lost, partly as carbon dioxide which escapes from solution during the progress of the preparation.

Since the Weiss and Downs process of making maleic anhydride has made maleic acid easily available, interest in the possible production of tartaric acid from this source has been revived. Accordingly, at the University of Chicago, Mr. Nicolas Milas and myself began the study of this problem. It soon became apparent that the Hofmann method was promising of control, and now after intensive study of it we have been able to make such modifications that we may transform either maleic or fumaric acid to tartaric with a 97+% efficiency.

The basis of our success was, first, that we secured a simple and rapid test for finding out when the reaction was complete, so that the resulting tartaric acids were not unduly exposed to the oxidizing agent which must be used in excess of that actually consumed by the change. The test depends on the fact that though bromine attacks the salts of fumaric or maleic acid with great speed, it attacks the tartrates only very slowly. To secure a water solution containing only a trace of bromine and not hypo-

bromus acid in harmful amounts a mixture of bromine and excess potassium bromide was used. A neutral solution treated with this reagent became decolorized in less than five minutes if either fumarates or maleates were present.

The next important fact discovered was that the carrier must be reoxidized with great speed relative to its reaction with maleic acid or fumaric. If this is not done maleic acid will be burned to form carbon dioxide, water, etc., and a heavy loss of material occurs just as in the case of the Hofmann experiment. Now the acid molecules of maleic or of fumaric acid are inert toward oxidizing agents but their ions react swiftly. Hence to cut down the rate of the reaction we employed the acids themselves instead of the acid salts as was done by Hofmann. Undoubtedly the reaction is between the carrier and the ions of the acid, but since the ions are furnished in low concentration the sodium chlorate can reoxide the carrier rapidly enough to avoid the above mentioned harmful effect.

The optimum temperature was found to be 50°, and the proportions of materials were 11.9 grams of sodium chlorate or the equivalent of other chlorates for 10g. of maleic acid and one tenth gram of osmiun tetroxide in 150 cc. of solution. The catalyst was recovered by extraction with benzene. From this solution it can be reclaimed by various well known reactions. The refining of the tartaric acid in the product may then be carried out by any of the well known methods for the purification of organic acids. We used the barium salt-sulfuric acid method.

As has been stated, the product of the oxidation of maleic acid is meso tartaric acid, and the product of the oxidation of fumaric acid is the racemic acid. The tartaric acid of commerce is the dextro acid, which combined with the laevo acid makes racemic acid. The separation of racemic acid into these two acids was first made by Pasteur and since his time others have carried out the separation by several methods. However, none of these methods is suitable for large scale work. Fortunately this separation is not necessary for the synthetic acids, and their salts resemble the dextro acid closely in all important characteristics.

HEAT OF FORMATION OF NITROGEN TRICHLORIDE

W. A. Noyes and W. F. Tuley, University of Illinois

(abstract)

A determination of the heat of formation of nitrogen trichloride was made by Troost and Hautefeuille more than fifty years ago, but the method which was used in making the determination was not described and no one has attempted to repeat the work. A few years ago the author found that the reaction between nitrogen trichloride and hydrochloric acid gives ammonium chloride and chlorine and is quantitative, and may be carried out in an anhydrous solution of nitrogen trichloride in carbon tetrachloride. This reaction has now been made the basis for a determination of the heat of formation of the compound and a value of about -54000 calories has been found.

ASYMMETRIC DYES AND THE MECHANISM OF DYEING

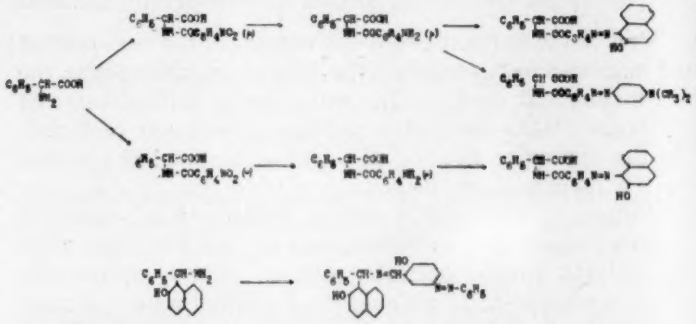
W. R. Brode and Roger Adams, University of Illinois

One of the earliest problems which excited the interest of men who were studying the field of chemistry was the mechanism of dyeing. In many books written between 1720 and 1800 a discussion of this problem may be found. Is the dyeing of fibres a physical or a chemical process, or a combination of the two?

Fibres of silk and wool are composed of optically active compounds, as determined by the fact that upon hydrolysis simple optically active organic compounds may be obtained. Consequently, if each of a pair of optically active substances is allowed to react with the fibres it may be expected that one would react more rapidly under similar conditions than the other. On the other hand, if the active substances were merely physically absorbed the rapidity of action should be the same for each of the pair. The problem, therefore, involved (1) the preparation of one or more pairs of optically active dyes, (2) the determination of the validity of the assumption that if the combination of such dyes with the fibre was purely physical in character the absorption would be the same for each of the pair, and (3) a determination of the speed with which the dyes react with the fibres under similar conditions. It was also necessary to be certain that the method for determining the amount of dye absorbed by the fibre was accurate.

The dyes which have been studied are of the azo type. One pair was made by the condensation of the active phenyl amino acetic acids with p-nitrobenzoyl chloride, reduction of the product to the corresponding amine, diazotiation of this latter substance and coupling with beta naphthol. A second pair of dyes was made by the same series of reactions except that the coupling was made with dimethyl aniline. A third pair was made by using o-nitrobenzoyl chloride in place of p-nitrobenzoyl chloride and the coupling with beta naphthol in the last step. A fourth pair was produced by taking the d and l forms of alpha beta-naphthol benzyl amine and condens-

ing with benzene azosalicyl aldehyde. The equations representing these syntheses are given below.



The degree of absorption of the optically active dyes by means of charcoal and kaolin was determined. With these absorbing agents there is no possibility of chemical reaction. All the experiments showed that a d dye was absorbed to the same extent as an l dye, and consequently the validity of the assumption that physical absorption of dyes by fibres would be the same for enantiomorphs was effected. The absorption of the racemic modification, however, was much greater than that of the active forms due to the fact that it was less soluble and more colloidal in character.

As the method for determining the amount of dye absorbed in a given time was by means of colorimeter readings before and after treatment of the standard dye solution with the fibres, the absorption spectra of the d and l forms of the dyes was determined. The bands were found to be of the same frequency both in the visible and ultra violet. A determination of the hydrogen ion concentration of a dye solution before and after treatment with the fibres indicated that there was a maximum change of 0.5 pH and that, therefore, the color change due to change in hydrogen ion concentration was negligible. A study of the effect of varying the hydrogen ion concentration showed that the absorption band does not change in wave length but merely in intensity, at least between 3 and 8.5 pH. Excess of acid or alkali causes sharp changes in the appearance of the band.

Repeated experiments under varying conditions with active dyes which had been very carefully purified showed that one form was absorbed to the same extent as its enantiomorph. The conclusion that can be drawn from these experiments is that the mechanism of dyeing is purely physical in character.

FURTHER IMPROVEMENTS IN THE FORMATION OF ALPHA-RAY TRACKS BY SIMPLE MEANS

CHARLES T. KNIPP, UNIVERSITY OF ILLINOIS

The simple alpha-ray track apparatus described and exhibited by Knipp and Sowers[1] at the Annual Meeting of the Academy held in May, 1924, has since been considerably improved and a brief note regarding it seems justified.

The apparatus in its present form is shown in Figure 1. It consists of a glass containing vessel blown into form from a pyrex breaker. The vessel in elevation is shown in (a), and (b) is a view from the top looking down. A battery syringe bulb, RB, is used for making the compressions and expansions. The vessel is filled to the point N through the tap T with distilled water, to which is added a trace of sulphuric acid. A tiny source of alpha rays is mounted in a protected cavity at the inner end of an aluminum plug, P. Two binding posts, C and D, make connection to the two electrostatic field plates, the upper plate being the moist glass surface, while the lower plate is the surface of the water. The electrostatic field is established between M and N. The electrical circuit required is also shown. The battery B may be

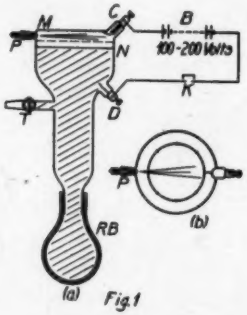


Fig. 1

any source of direct current, as an ordinary B battery in radio. A lantern is needed for general illumination. Recently we are using a 75 watt, 110 volt, madza lamp for this purpose with good results.

[1]Trans. Ill. State Academy of Science. Vol. XVII. 1924. p. 121.

To operate the apparatus the hand bulb, RB, is squeezed slowly and then released suddenly. This is repeated, increasing the compression, until the proper ratio is obtained, whereupon the tracks will appear freely, being very distinct and persisting for some moments. Oftentimes the tracks travel the full length of the chamber. Many of the phenomena that Wilson described may be studied. There seems to be no deterioration with time. The rays form just as freely after the apparatus has stood a month as when first set up; in fact, they seem to form more freely, coming from other parts of the vessel. This undoubtedly is due to the emination from the radio-active material.

Laboratory of Physics,
University of Illinois,
February 18, 1925.

A STUDY OF COLORED HALITES

T. E. Phipps and G. C. Mason, University of Illinois

In this work two types of colored halite were studied comparatively: the deep-blue, naturally occurring halite, hereafter called "Stassfurt blue halite", and halite colored by heating in contact with sodium vapor to temperatures between 500°C and 750°C, hereafter called "artificially colored halite".

The deep blue color of naturally occurring Stassfurt halite attracted the attention of Sir Humphrey Davy in 1818, and until the present time, though many researches[1] into the cause of the color have been undertaken, a satisfactory explanation is still lacking. The following causes among others have been assigned for the color: presence of organic matter, presence of alkali sub-halides, presence of an allotropic modification of the chloride, presence of a solid solution of sodium metal in the salt, and finally, presence of colloidal particles of free metal. Zsigmondy[2] in 1905 suggested the colloidal metal theory, and it has been accepted by many colloid chemists, notably, Siedentopf[3] and Svedberg.[4] Sidentopf studied the Stassfurt blue crystals with the ultra-microscope and published patterns of what he believed to be ultra-microscopic particles of sodium in the halite lattice. Siedentopf's evidence was questioned however by Spezia[5] who failed to find any trace of alkalinity to indicators in water solutions of the blue salt. Several other investigators agree with Spezia as to the non-alkalinity of such solutions.

Ordinary colorless halite can be colored by heating it in contact with sodium vapor to temperatures between 500°C and 750°C. This is done most easily by sealing up thin halite crystals with sodium in an iron crucible with high temperature cement, and heating in an electric furnace for an hour or more. The color obtained depends upon the heat treatment given the crystal. Most fre-

[1] A complete summary may be found in Mellor's *A Comprehensive Treatise on Inorganic and Theoretical Chemistry*, Vol. II, p. 530 et seq.
[2] *Zur Erkenntnis der Kolloide*, Jena, 58, 1905.
[3] Chem. Centr. I, 388-389, (1906)
Also a later paper in 1912.
[4] *Kolloide Losungen*, Dresden und Leipzig, 483, 1922.
[5] Centr. Min. 394-404 (1909).

quently a purple or heliotrope blue is obtained at lower temperatures; and a pink changing to a pale straw color results from heating to temperatures nearer the melting point of the crystal. It is conceded by all investigators that these crystals contain free sodium, visible ultramicroscopically, and that their water solutions are alkaline.

In general the two types of colored crystals behave quite differently toward heat, the Stassfurt blue fading out at about 300°C, the artificial color persisting (though faintly) up to the melting point. Nevertheless it is possible to prepare artificially colored crystals which match Stassfurt blue crystals fairly closely both as to visual tint and depth of color. It occurred to the authors that by means of the hydrogen electrode the alkalinities of water solutions of the two types of colored crystals could be compared more accurately than by indicators, and that the question as to the alkalinity of the Stassfurt blue crystals could be decided.

After several attempts to adapt the Hildebrand and other types of hydrogen electrode to the problem, the electrode shown in Figure 1 was designed. The Pyrex electrode vessel is of the captive hydrogen type, and combines features of the Clark and of the Bailey vessels. It has the following advantages: (1) it comes to quick equilibrium, (2) it can be stirred simply and effectively by tilting back and forth a few times, thus eliminating complicated mechanical stirring, (3) after the first few rapidly performed steps it is protected from further contamination by the carbon dioxide of the air, (4) the electrode is easily replaceable, and (5) the trap connection to the calomel half-cell gives steady boundary conditions between the two liquids. The operation of the electrode is as follows:

The vessel (Fig. 1) is completely filled with CO_2-free conductivity water, and while it is held in the position shown in Fig. 1, it is about half filled by downward displacement with purified electrolytic hydrogen led in through C. A weighed crystal is dropped into the bend, and the ground glass stopper D is seated so as to completely exclude the air. Equilibrium in then quickly ob-

tained between hydrogen, solution, and electrode by one or two minutes of vigorous shaking. Then with the arm A vertical, as in Fig. 1, the stopper D is removed and connection is quickly made to the saturated KCl calomel electrode (Fig. 2) by slipping the arm B over F and engaging the rubber stopper G, the arm A still being kept

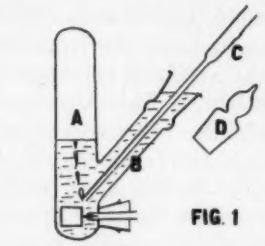


FIG. 1

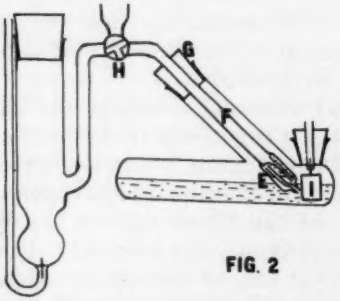


FIG. 2

vertical. This puts a slight pressure upon the hydrogen, and when H is opened to the atmosphere, solution runs up into the trap E, about half filling it and resting upon the denser saturated solution of KCl below. The arm A is then turned to a horizontal position (shown in Fig. 2) by rotating the stopper G about its axis. The E. M. F. of the combination is measured by a Leeds and Northrup Students' Type Potentiometer. Ordinarily, steady readings are obtained within two or three minutes. At the end of the run the hydrogen electrode is disconnected at G, the total volume of the solution is measured, the trap E is flushed out with saturated KCl, and another run is started.

Measurements were made upon solutions of (1) Stassfurt blue crystals, (2) Crystals cleaved from the colorless

portions of large Stassfurt blue specimens, (3) Colorless crystals from Navarre, Michigan, (4) Crystals from both Stassfurt and Navarre, colored artificially in sodium vapor. Table I gives results representative of more than a hundred such measurements.

TABLE I.

Dissolved Salt	Color	pH value of solution	Normality of free sodium in crystal
Artificially Colored NaCl			
1	Red	6.28	2.01×10^{-6}
2	Green	7.94	1.46×10^{-4}
3	Pink	8.81	2.26×10^{-3}
4	Pink	7.62	1.59×10^{-4}
5	Blue	6.43	5.02×10^{-6}
Colorless NaCl, Navarre			
1	.....	5.87	Zero
2		6.07	Zero
3		6.09	Zero
4		6.02	Zero
5		6.05	Zero
Colorless NaCl, Stassfurt			
1	.....	6.04	Zero
2		6.07	Zero
Stassfurt Blue NaCl			
1	Deep blue	6.04	—
2	Deep blue	6.05	—
3	Deep blue	6.04	—
4	Deep blue	5.98	—
5	Deep blue	6.04	—

Solutions of the colorless crystals and of the Stassfurt blue crystals gave practically identical PH values, while the solutions of the artificially colored crystals invariably gave markedly alkaline solutions,—sometimes 0.001N or greater. Calculation showed that the maximum concentration of free sodium which (because of limitations of the method) might be conceded to be present in the Stassfurt blue crystal is of the order of magnitude 1×10^{-8} normal, or one one-hundred-millionth normal. In view of the fact that Kraus has stated that the dilute solution of sodium in liquid ammonia whose *very faint blue* is still just visible, has a concentration of one forty-thousandth normal, or 2.5×10^{-5}, it seems highly improbable that the color in the case of a *deeply colored* Stassfurt crystal could be due to free sodium. There is no case on record, so far as the authors know, where coloring matter in concentrations less than one forty-thousandth normal has been observable.

As to the cause of the color in Stassfurt blue halite this investigation gives no positive evidence. Negatively, it denies the possibility of the color's being due to free metal, and thus throws serious doubt upon the colloidal theory of the color. More specifically the interpretation which Siedentopf gave to his ultra-microscopic data is called into question.

Recently several investigators, notably Lind and Bardwell, have ascribed the colors obtained by treating various crystals with radium emanation to the displacement of certain electrons from their normal position in the crystal lattice. We quote at some length from the concluding paragraphs of their recent paper:[6] "Certain groups of electrons are displaced by radiation from their normal positions and take up new metastable positions among the atoms. No displacement (or only secondary displacement) of the atom is involved. No change in the crystal lattice as revealed by X-rays would be expected nor would there be any production of colloidal particles. One or more groups of electrons may be involved. * * * It appears to us probable that the color is due to the vibration of electrons in their abnormal positions. * * * Since the crystal is transparent the color complementary to the one absorbed by the electronic vibration is transmitted. In the metastable positions, under less constraint, the electrons are also freer to take part in electrical conduction and in photo-electric emission under radiative stimulus, and can also return to their normal positions under this stimulation or by that of heat."

It seems very probable that the ultimate explanation of the Stassfurt blue color will come with the development of this theory of electronic displacements in crystal lattices. Further work is being carried on in this laboratory to determine the conductivities of the two types of colored crystals over a wide range of temperature. The change of the absorption spectra with temperature is also being studied.

Contribution from the
Chemical Laboratory
of
The University of Illinois

[6] Lind and Bardwell, Journal of the Franklin Institute, 196, 375 (1923)

INVESTIGATION OF ANTENNAE AND OF RADIO TRANSMISSION BY MEANS OF MODELS

J. TYKOCINSKI-TYKOCINER, UNIVERSITY OF ILLINOIS

I. ANTENNAE.

The most essential parts of a radio station are the transmitting and receiving antennae. The radiation of antennae as well as the propagation of electromagnetic waves over the surface of our globe constitute the fundamental phenomena underlying the art of radio communication. In this domain the phenomena to be studied take place in the space surrounding our planet. The waves reach the highest layers of the atmosphere and they penetrate even the surface layers of the earth to a considerable depth.

Every antenna consists of a system of wires supported on masts or towers and extending above the surface of the earth. During the process of radio transmission electromagnetic waves are detached from the antennae and forced to radiate into the surrounding space.

Besides its geometrical dimensions every antenna possesses physical properties characterized by a number of constants which can be determined by measurements. The principal constants of an antenna are the following: fundamental wave length, static capacity, dynamic capacity, inductance, ohmic resistance and radiation resistance.

Full size antennae are expensive, their principal dimensions cannot be easily varied so as to maintain others constant, and they are not always available for carrying on experiments. Investigations were therefore carried out at the Engineering Experiment Station of the University of Illinois to find out whether workable antennae models could be made, and if satisfactory, whether they can be used for the determination of constants of typical antennae. M. Abraham gave us the theory of a long, rod-shaped Hertzian oscillator, which represents an idealized simple antenna, and G. W. Pierce in this country extended this theory to a flat-top antenna. In his dissertation on *Electric oscillations around a rod-shaped conductor, treated according to Maxwell's theory*, Abraham deducted mathematically about 12 fundamental properties of oscillators of this ideal type. Two of those

theorems which concern directly our problem may be mentioned:

I. "The natural periods of geometrically similar oscillators are related to each other as the lengths of respective segments."

II. "The natural periods of geometrically similar oscillators possess an equal logarithmic decrement."

The first of the two theorems means that given two oscillators, one having its geometric dimension m times smaller than the other, it will emit a wavelength also m times smaller. The other theorem means that the logarithmic decrement of both oscillators, the larger as well as the one which is m times smaller, will be exactly equal. In his theory, Abraham assumed the ohmic resistance of the oscillator to be zero, so that the decrement of the oscillator is due exclusively to radiation. It follows that the radiations of geometrically similar oscillators having negligible ohmic resistance are equal, no matter how large or small they are made.

These two theorems could be raised to a general principle of similitude for all antennae. However, we must gather sufficient evidence to prove that it applies to all oscillators, including antennae of all types.

Before the experimental investigation of models was started, it was clear that even in case a simple relation is not discovered between the model and the original antenna, the study of models promises nevertheless to disclose sufficiently interesting material in connection with properties of radiating systems. To gain a basis for the work, known formulae having any relation with the processes going on in antennae were examined. A rigorous proof was not obtained that from the behavior of a model it will be possible to make conclusions about all properties of a full size antenna. Nevertheless, sufficient evidence was collected to encourage the investigation.

Antenna models may be used either for teaching or for research purposes, especially for predicting those data the knowledge of which is necessary for proper designing of radiating systems adapted for radio communication. Considering the small size of a model, the

use of very high frequencies becomes necessary. Apparatus for the production and measurement of currents of very high frequencies by means of thermionic tubes were developed, ranging from 50 to 100 million cycles per second and corresponding to wavelengths of 6 to 3 meters.

Fig 1 shows such a short wave transmitter coupled with the simplest form of an antenna—a Hertzian oscillator.

To demonstrate the origin and the chief properties of antennae all that is necessary to do is to replace one-half of the Hertzian oscillator (Fig. 2) by a mesh held rigidly in a frame clamped to a table and to substitute a rod in place of the other sphere. Thus a simple model of a T-antenna is readily built. By drawing the upper rod out of the connecting T-piece the same antenna is transformed into the inverted L type.

Mushroom form and other types of antennae can be reproduced in the same way by means of a few rods and connecting pieces available in every school laboratory. The vertical rod of the antenna is supported by a board fixed to the table by means of clamps. The general dimensions of the models can be estimated from the illustrations by comparing with the size of the meter stick fixed to the edge of the table. The transmitter is placed in a vertical position so as to enable one to observe the measuring instruments.

For the purpose of experimental research more elaborate constructions of antennae models are required. All those details of antennae systems met in practical construction which may have any influence upon its electrical characteristics have to be considered in the model. So the height and the material of the supporting structure, neighboring dielectric or conductive masses, electric properties of the ground and other details may be taken into consideration.

One of the models used for investigations is illustrated in Fig. 3. It is a model of a flat top antenna supported on three masts. The base of the model consists of a wooden frame supported on four legs. The frame, covered beneath with a copper sheet, forms a tray which can be filled with any material of proper conductivity to

approach the properties of the ground. Crosspieces can be shifted and clamped by means of a wooden screw in any convenient position along the frame. Carriages are made to be moved along the crosspieces and to be likewise fixed in any convenient place. These carriages have vertically bored threaded holes into which the bases of standards are screwed, serving to support the antenna wires. The number of cross pieces and carriages to be used depends on the number of masts employed for supporting the antenna wires. In the figure two cross pieces and three carriages are shown with three masts. Hard rubber insulating pieces or rubber bands can be shifted along the masts to set the antenna wires at any desirable height above the ground plate. Two antenna wires are visible in the figure ascending from the ammeter towards the top of one of the masts from which they extend, diverging towards the top of the two other masts. The cross pieces have extensions, reaching 50 cm. beyond the frame, and made to carry a baseboard for the short wave transmitter. By moving this board parallel to the frame the coupling of the transmitter with the antenna can be regulated. Finer adjustment of the coupling is carried out by means of the handle designated to rotate the plane of the transmitter loop.

It is possible to determine the chief characteristics of every type of antenna by preparing a model of the described kind. The natural wavelength, the static as well as the dynamic capacity, the total and the radiation resistance can be determined, and from the values obtained by measurements, the inductance, the losses and the efficiency of a given antenna can then be calculated. The scale of the model is limited on one hand by the space available; on the other hand by the thickness of the wires we may use for the antenna model. If the model is too large, a special building is required to house the structure; if it is too small, thin wires have to be used, possessing too small strength and introducing too large a resistance in the antenna circuit.

For antennae corresponding in size to average ship antennae a model about 1/50 to 1/100 of the original may be used, but for the large antenna of a trans-Atlantic station a scale of 1/250 to 1/500 may be practical.

FIG. 1. Short Wave Transmitter with Hertzian Oscillator Coupled with it.

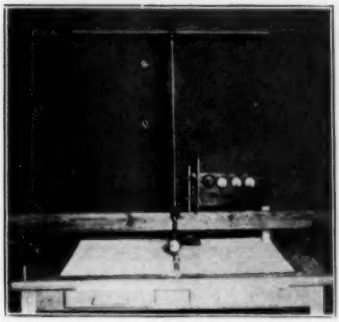


FIG. 2. Model of a T-Antenna for Teaching Purposes.

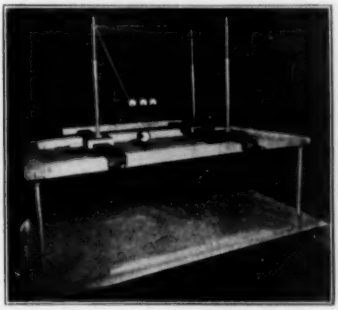


FIG. 3. Model of a Flat-top Antenna Supported on Three Masts.

The methods of measurements employed in connection with the determination of antennae constants are in principle identical with those used on full size antennae, but the technique had to be modified and adapted to the use of short waves and nonquasi stationary circuits.

A special wavemeter had to be constructed for precise determination of short wavelengths. The condenser consists of a pair of circular discs, of which one can be rotated. Both inner surfaces of the discs facing each other are divided into two equal semicircular parallel parts, each of them on a somewhat different level. The step-like discs are mounted in a cylindrical bakelite box. Of these condenser members the stationary one is fixed to the bottom of the box, while the rotating one is set on a circular brass plate of somewhat larger diameter. The latter fits into the opening of the box and is pressed by means of a star like spring and by the bakelite cover against a bronze ring fixed in the box above the stationary condenser member. The inductance consists of one turn of brass strip bent into a narrow rectangular loop. The loop can be rotated around the condenser and brought into every position convenient for performing the measurements, without the danger of changing the constants of the wavemeter. This is possible because of the symmetrical shape of the condenser. It was found convenient not to use any indicator connected directly with the wavemeter. The loop of the wavemeter is directed towards the transmitter, and the calibrated condenser varied until the ammeter in the transmitter circuit indicates minimum of deflection. This takes place when the wavemeter circuit is in resonance, absorbing maximum energy from the 5-watt tube transmitter.

The accuracy of the antenna wavelength measurement depends largely on the damping of the particular circuit. Comparative measurements of a 1/100 scale model of a T-antenna supported on wooden masts, having its two horizontal wires 60 cm. above the ground plates, 75 cm. long and separated 6 cm. from each other, gave 490.5 cm. for the fundamental wavelength, while the original ship antenna represented by the model has a wave length of 510 m. If, however, steel rods with guys were used to support the model antenna its wave length increased to

509.5 cm. This value multiplied by the model coefficient 100 gives a very close agreement with the wave length of the full-size antenna.

The precision with which wave lengths of antennae can be determined by models suggests the use of the described methods for the study of wave length and other constants as affected by the change of the relative position of antenna wires. In a model illustrated in Fig. 3, the length of the wires and the height of the horizontal wires above the ground plate were kept constant while the angle between the top wires was varied. New positions were obtained by separating the masts supporting the ends of the two horizontal wires, when the fundamental wave length of the antenna was determined by measuring that frequency of the oscillating transmitting circuit, which produced maximum current in the antenna. The results obtained show that the wave length increases with the angle enclosed between the two top wires at a rate decreasing as this angle becomes larger. A variation in wave length produced by the relative change of position of wires equal to an angle of only 1° can be detected.

Measurements of the static capacity of the T-antenna model mentioned above gave a value of

$$C = 11.95 \text{ cm. e. s.}$$

for the antenna supported on wooden masts. If, however, steel rods 1.2 cm. in diameter placed directly on the ground plate and stayed by insulated guys of copper wire were used to support the antenna, the value

$$C = 14.6 \text{ cm. e. s.}$$

was found. The static capacity of the full size ship antenna similar in form to the model but 100 times larger is known to be 1400 cm. The discrepancy of about +4.25% may be due partly to the arrangement of the guys, possibly differing from the actual conditions, partly to the influence of the surrounding walls and objects in the laboratory where the measurements were made.

For radiation measurements a model of receiving antenna was used, supported on a wooden frame covered with a copper ground plate of exactly the same dimensions as for models of transmitting antennae. This

frame carries on a bakelite plate attached to two carriages a telescopic antenna consisting of two brass tubes sliding one into the other. The inner tube, which may be fixed at any definite height by means of a set screw, carries at the top a brass cup with a funnel like channel ending at the lower part with a fine hole. Through this hole a bronze wire slides out of the tube over the cup. The wire carries a counter-weight moving inside the antenna tubes which can be pulled out by means of a cord attached to an elastic insulator fixed to the other end of the wire. The cord leads over pulleys to the place where observations are made and is used to tune the receiving antenna to the frequency of the transmitting antenna by altering the length of its horizontal part formed by the bronze wire. The base of the antenna tube is connected through a thermocouple and resistance element to the ground plate. A pair of leads connects the thermocouple with a sensitive galvanometer.

The earliest method employed for radiation measurements was that suggested by Erskine-Murray for actual antennae which were coupled with quenched spark transmitters. This method was cumbersome and beset with the difficulties encountered with the lowering of antennae without considerably disfiguring their geometrical shape. But it is comparatively easy to use this method of radiation measurements on models of those types of antennae for which the ohmic resistance is small in comparison with radiation resistance. The measurements of radiation on such models must be carried out in a field free from buildings, trees and overhead wires, within a radius of at least 10 wave lengths, in order to avoid reflection, refraction and absorption of the waves.

The first radiation measurements with models were undertaken in Urbana on the grounds extending south of the Electrical Engineering Laboratory under very unfavorable conditions. With the model of a T-antenna described above but with the ground plate set directly on ground the following results were obtained:

Radiation resistance measured	s = 14.8	ohms
Resistance of thermoammeter measured		
Ohmic resistance of antenna bronze wires, calculated	r = 4.6	ohms
	3.3	ohms
	2.5	ohms
Balance for the earth resistance		
Total antenna resistance measured	R = 25.2	ohms
Effective height of antenna calculated	h = 49.8	cm.
Current distribution factor calculated	b = 0.81	

The value of s=14.8 ohm is approximately equal to the value of radiation resistance known for actual antennae of this type.

More details on antennae models will be published by the University of Illinois in a bulletin, No. 147, of the Engineering Experiment Station.

II. RADIO TRANSMISSION.

The problem of radio transmission calls for extensive experimental research on wave propagation. By reviewing the great number of investigations made during the last twenty years by prominent mathematicians and physicists (Macdonald, Rayleigh, Henri Poincare, A. Sommerfeld, F. W. Nicholson, H. J. Love, C. N. Watson, L. Austin, W. Eccles, J. Zenneck, etc.), we are forced to admit that our knowledge of the propagation of electromagnetic waves of the kind used for the purpose of radio communication is still in a chaotic state. No general principles have as yet been evolved which correlate the data obtained by years of patient observation. The discrepancies between the values of electric field intensities calculated according to various hypotheses and the actual intensities measured at points a considerable distance of about 3000 to 12000 km. away from the transmitting antennae grew larger and larger in progression with the practical achievements of radio engineering.

L. Austin made a series of very valuable experimental investigations, studying variation of signal strength for distances of 1000-3000 km. He investigated also the influence of day and night and succeeded, in collaboration with Louis Cohen, in finding an empirical formula embracing all his observational data, obtained by measuring the intensities of reception during day time over the surface of the sea. Austin's formula, giving the relation between the current in the receiving antenna and other

factors entering into play, whenever radio communication between two points has to be established, marked a conspicuous advance in the art. It was shown by C. N. Watson in 1919 that Austin's empirical results can be deduced theoretically if the conducting layer suggested by Heaviside and Kennelly is placed at a height of 100 km. above the surface of the earth and if the specific resistance of this layer is 0.695 million ohms per cubic centimeter.

It seemed, therefore, that the Austin-Cohen formula represents the true relations of wave propagation at least over the surface of the sea.

However, recent years have added new experience in the transmission of waves over long distances. In fact the largest distances of transmission possible on our tiny globe have already been attained and observations have been made with receivers placed near the antipodes of the transmitting stations. The French navy undertook in 1920 to measure on board the Aldebaran the strength of signals emitted from the long distance stations in Nantes and Lyons. It was found that for distances greater than 3000 km. the signals were much stronger than would be expected from Austin's formula.

In the spring of 1923 a new long distance radio station was completed in Karachi, India. This occasion was used to measure the field strength of British, French and Italian stations at a distance of about 6000 km. The values obtained were 60-300% larger than the values calculated from Austin's formula. The discrepancy is even larger, if we consider that the largest circles connecting Karachi with the respective transmitting stations passes over land, while Austin's formula was deduced from experiments over sea.

The advance made during the last year (1924) by demonstrating the effectiveness of short wave lengths lying between 35 and 100 meters revealed the astounding fact that the application of Austin's empirical formula for a wave length of 100 m. at a distance of 12000 km. gives values of field intensities 10^{24} times smaller than those obtained by measurements. Investigators must be aroused to consider the chaotic state of knowledge in this very important domain and to devise means of discov-

ering the fundamental causes of disagreement. Mathematicians will hardly be in a position to master the problems without an adequate supply of reliable facts which can be gained only by constructive experiments. Not much can be expected from a passive observation of diurnal, seasonal and other variations of signal strength due to erratic meterologic and cosmic causes. Results obtained from occasional expeditions organized by the Navies, in this country and abroad, are not sufficient for a systematic study of the role which a great variety of physical conditions our globe's atmosphere and its surface layers exert on the propagation of waves. More extensive experimental researches are required to be carried out under conditions variable at will by the investigator.

It may be asked, however, whether it is at all possible to accomplish anything in this respect in a laboratory. Indeed, not much can be done in a physical laboratory of the usual kind. Special observational stations or a laboratory of an unusual type will have to be developed. However, the enormous expenditures involved in the creation of such a laboratory makes its realization impossible at the present time.

Nevertheless, it may be useful to consider the conditions under which an experimental study of fundamental problems of wave propagation could be accomplished. An Earth Globe Model, as illustrated in Fig. 4, represents an ideal laboratory as may be suggested for the purpose of investigating radio transmission.

Imagine a spherical cave (c) about 15 m. beneath the surface of the earth and extending 300 m. deep. In the center of the cavity a spherical airship 260 m. in diameter is held floating. In the vertical axis of this floating sphere is placed a supporting structure (column s) having dimensions similar to those of a modern airship. This column (s) carries inside bags (b) filled with Helium sufficient in quantity to keep the whole structure floating. The same column is used to support about 60 trusses (t) hinged at (h) and forming the skeleton of a globe model. Ropes connect every hinge (h) with a drum placed in the equatorial plane of the supporting column. By releasing

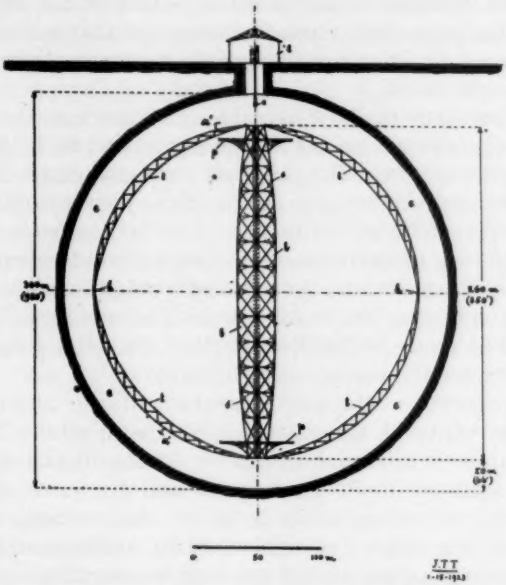


FIG. 4. Earth's Globe Model Suggested for the Study of Propagation of Electromagnetic Waves.

the ropes, the shape of the model can be changed. A radial displacement of the hinges by only 70 cm. will produce a depression making the model identical in shape with the terrestrial spheroid. In order to allow for this kind of form variations, the upper hinges of the trusses (t) are attached to a tube sliding over a cylindrical extension of the supporting structure (s).

The outer surface of the globe is covered with a light textile material so treated with conductive dyes as to imitate the geographical distribution of the various electric properties of the earth's surface. The relief of the continents and even artificial obstacles could be produced by suitable modeling materials. All points on the surface are accessible in order to attach there model antennae. The lower platform (p) carries electric apparatus and batteries for the production of short wave oscillations, with which the model antennae will have to be excited. The receiving antennae used for measuring

the field strength at any desired points of the globe are all to be controlled from the same platform inside the globe, so that measurements could be accomplished from one central point.

A laboratory of the dimensions indicated on the sketch would represent a model in size equivalent to 1/50,000 of the earth's globe. The layer of air between the wall of the cave and the surface of the globe corresponds to an atmosphere 1000 km. in height. The largest wave length in use in long distance radio telegraphy would correspond to a length of 60 cm; the highest antenna in use would correspond to a length of 6 cm. The conductivity will have to be made 50,000 times larger than the actual conductivity of the oceans and continents.

To generate a state of ionization of the atmosphere various points of the cave receive installations for the production of ultraviolet light or corona discharges. A gallery can be made winding around the cave spirally from top to bottom so as to allow observations at any point of the cave. Special electric arrangements are feasible to produce at definite heights sheaths or clouds of ions to act as Kennelly-Heaviside layers. Further developments will make posible the production of variations of humidity, temperature, magnetic field, and also electro-magnetic disturbances.

Near the entrance to the cave an above-ground laboratory (1) and a workshop serves for the auxiliary work to be done in connection with the investigation on the model. The communications with the upper laboratory are performed by means of a suspended elevator cage (d) descending the cave opening and down the inner column. During the experiments the elevator cage is lifted and the entrance to the cave closed, so that the earth's model is floating in the cave entirely insulated from the laboratory.

Investigations of fundamental importance will be made possible on the model by suppressing certain complicating influences, by creating at first ideal conditions of uniformity in the medium of wave propagation, and then only varying and combining the predominating factors, influencing the propagation of energy radiated by different antennae systems. So the influence of wave length,

of the geometric shape of the globe, of the conductivity of its surface, the absorption, refraction, and reflection of waves due to ionization, earth's magnetic field, and of other factors can be studied.

There is no reason why, after a period of extensive building of libraries, astronomical observatories, medical research institutes, etc., there may not come a time for a special wave propagation laboratory of the described type.

From the investigations carried out with model antennae the following conclusions may be drawn:

1. The characteristics of full-sized antennae can be predicted by means of miniature models to scale of about one to one hundred excited by proportionately short waves from three to six meters long.

2. The wave length, static capacity, effective capacity and effective height of the model can be determined with sufficient accuracy for the design of full sized antenna installations.

3. The relation of these characteristic constants of full-sized antennae to the corresponding values as determined with accurate models is the simple ratio of linear dimensions, noted as "m" in this paper.

4. The determinations of radiation resistance by means of models approximate measured values of actual antennae. The slight discrepancies are believed to be due chiefly to presence of interfering objects.

5. Special simple forms of adjustable model antennae permit the rapid comparison of variations of form or dimensions as affecting the performance of full-sized antennae. This type of model serves for the purpose of demonstrating the properties of various types of antennae.

6. The results of any suggested alteration in the form or dimension of full-sized antennae are convincingly shown leading rapidly and economically to the production of the most satisfactory structure of any general type.

7. A new type of condenser and of wavemeter have been developed permitting remarkable precision of measurement of the two to ten meter waves.

8. Radio transmission around a spheroid may be experimentally investigated by means of antennae models distributed over the surface of a suggested earth globe model.

THE PREPARATION OF HYDROGEN ELECTRODES

GERHARD DIETRICHSON AND C. N. SHAH, UNIVERSITY OF ILLINOIS

The electromotive force established at the junction of a gaseous or a metallic conductor and an electrolytic conductor represents essentially the work involved in the taking on of electrons at the cathode and the giving up of electrons at the anode. Theoretically, in the case of gas electrodes, this potential difference should be independent of the metallic conductor used for making electrical contact with the gas, provided it does not react chemically with the latter or the solution in which it is in part immersed. It also follows that if the electrode, for example, hydrogen, is a reversible one, its potential when acting as a cathode in an electrolytic cell or an anode in voltatic cell should be the same. In practice, however, it is found that because of irreversible effects of one form or another, these conditions are not realized. The problem therefore of determining the methods for the preparation of gas electrodes that most nearly approximate a reversible system becomes an important one. This is especially true in the case of the hydrogen electrode in view of the very extensive applications that have been made of the electromotive forces associated with theH_2, H junction or the $H_2 \leftrightarrows 2H + 2$ (-) electrode reaction.

The early work of Le Blanc[1] first established the hydrogen electrode as a reversible system. Smale[2] and Wilsmore[3] in their subsequent researches came to the same conclusion. Following these early investigators there are a considerable number of others who have studied it with special reference to its constancy and reproducibility. Among these may be mentioned in particular Loomis and Acree[4], Lewis[5], Ellis[6], and Clark[7]. Other workers have confined themselves more particularly to the applications of the hydrogen electrode. In spite

[1] Le Blanc. Z. Physik. Chem. *12*, p. 333 (1893).
[2] Smale. Z. Physik. Chem. *14*, p. 520 (1900).
[3] Wilsmore. Z. Physik. Chem. *35*, p. 296 (1900).
[4] Loomis and Acree. J. Physic. Chem. *19*, p. 660; J. Am. Chem. Soc. *48*, p. 621; J. Am. Chem. Soc. *46*, p. 585.
[5] Lewis, Brighton, and Sebastian. J. Am. Chem. Soc. *39*, p. 2245.
[6] Ellis. J. Am. Chem. Soc. *38*, p. 742.
[7] Clark, W. M. Determination of H+I on concentration. 2nd Ed. 1922.

of all the work carried out in the past there has still been much uncertainty as to the best procedure to follow in the preparation of the electrodes, particularly with regard to the current densities and composition of solutions which are most suitable. The situation in this respect is summed up very well by Clark in the second edition of his book on "The Determination of Hydrogen Ions". On page 177 the following statement appears: "No detailed descriptions have been found in the literature and those that are found are quite inadequate to account for the varied deposits sometimes formed." The present paper represents an attempt to supply some of this information.

The three materials most commonly used in the preparation of hydrogen electrodes are electrolytically deposited platinum, palladium, and irridium. The latter is recommended by Lewis, Brighton and Sebastian[8]. Two objections to the use of irridium are the high cost of the metal and the extreme difficulty of getting it into solution. In the case of palladium it is easy to obtain electrolytic deposits but it was our experience that these deposits did not adhere well, especially when the electrodes were used in acid solution. As regards the procedures previously described in the literature for the preparation of the platinized platinum electrodes, comparatively few of these make use of solutions of the pure chloroplatinic acid. Whenever this is done the metal is usually described as being deposited by means of a commutated current with a sufficiently high current density to cause a copious evolution of gas at each electrode. Some writers call attention to the difficulty of depositing platinum from solutions of chloroplatinic acid alone. This is illustrated in the following statement as made by Fox[8]: "It is not possible to get a good deposit of platinum black on a very pure specimen of platinum foil, if the platinum chloride solution employed is also very pure. A trace of lead acetate is usually added to the solution, therefore, and it is necessary to remove every trace of this from the electrode after coating, or good values are unobtainable." The experience of the writers was similar to that of Fox both with regard to the deposition of platinum directly on a platinum base and the use of lead acetate.

[8]Fox. Chem. News. *100*, p. 161.

In view of the situation as described above it was decided to investigate in a somewhat systematic way the necessary conditions for the deposition of platinum in a form suitable for hydrogen electrode purposes from solutions of pure chloroplatinic acid. In this connection attention might first be called to the electrode process involved. The reaction resulting in the deposition on the cathode of the metallic platinum is presumably that represented by the equation

$$PtCl_6'' + 4\,(-) \rightarrow Pt + 6\,Cl'$$

The problem involved in particular a study of the concentration and the current density relations and also of the character of the metal to be used as a base. For this purpose the following plan was adopted. Solutions of chloroplatinic acid obtained from the Bureau of Standards were prepared, ranging in concentration from one to six percent by weight of acid. Electromotive forces varying in steps of 0.2 volt were impressed across the platinum foil electrodes of one sq. cm. until a deposit was formed on the cathode. Following this the effect of increasing the current density was noted. It was found that good, black, velvety deposits could be obtained, provided the current density was kept low and the concentration sufficiently dilute. As regards the current density, the results were best when the electromotive force was so adjusted as to just prevent the evolution of hydrogen at the cathode. When higher current densities were used the metal did not adhere properly. The concentration found to be most satisfactory was a 1-2 percent solution. With an increase in concentration the deposit became gray and crystalline; when the six percent solution was used it was distinctly crystalline in appearance—a form altogether unsuited for hydrogen electrode purposes. On account of the low current density the time required is necessarily longer than would otherwise be the case. It was found that a uni-directional current passing for from three to four hours would give a uniform black deposit that adhered very well to the electrode.

The condition of the surface of the electrode is obviously a very important factor in getting good deposits. In this connection we found that it was much easier to

bring about a satisfactory deposit of platinum if the electrode was first gold plated. In the case of old electrodes the gold plating appears to be almost a necessary prerequisite. One advantage of electrodes prepared with a gold base is that they seem to require less time for saturation with hydrogen gas. Also, the process of cleaning the electrodes is much simpler than if the deposit is made directly on a platinum base.

Electrodes prepared in this manner described above were tested in considerable numbers. The results were very satisfactory both as to constancy and the electromotive force values for electrochemical systems. The electrodes have also been used by students in electrochemistry courses with better results than previously obtained by other methods.

THE VARIATION OF THE DECLINATION DURING THE SOLAR ECLIPSE OF JANUARY 24, 1925, AT URBANA, ILLINOIS

CHARLES T. KNIPP, UNIVERSITY OF ILLINOIS

It is not very often that the path of totality of an eclipse of the sun passes twice successively across the same region. And it is only comparatively recently that the magnetic effects during an eclipse have been studied. The first systematic observations were begun at the time of the solar eclipse of May 28, 1900.[1]

The eclipse of June 8, 1918, offered an exceptional opportunity for astronomical, geophysical, and magnetic observations, since the path of totality passed from the state of Washington in a southeasterly direction through Wyoming, Colorado, Kansas, Arkansas, Alabama, and Florida. The magnetic work was under the direction of Dr. L. A. Bauer of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. It was planned to collect data at a number of stations with reference to the variation, during the time of the eclipse, of the declination of the compass needle. The observations of 1900 had suggested that there is an effect, and the eclipse of 1918 afforded the first opportunity in this country of continuing systematic observations. Accordingly magnetometers designed for declination studies were set up at some 16 stations along the belt of visibility, —seven of these stations were within the path of totality.

The department of physics, University of Illinois, was asked to co-operate, as also were a number of departments at other institutions outside of the belt of totality. The results were worked up by Dr. Bauer and his associates and published in Terrestrial Magnetism and Atmospheric Electricity.[2]

The conclusions, in part, drawn relative to the eclipse of 1918, were:

a) *"That there is an appreciable variation in the earth's magnetic field during a solar eclipse.*

[1]Terr. Mag., Vol. 5, 1900, pp. 143-165.
[2]Terr. Mag., Vol. XXIII, No. 3, Sept. 1918; Ibid. Vol. XXIII, No. 4, Dec. 1918; Ibid. Vol. XXIV, Nov. 1, Mar. 1919.

b) *"The magnitude in the variation of the declination is about .1 to .2 that caused by the solar diurnal variation on undisturbed days.*

c) *"The general character of the solar-eclipse magnetic variation is the reverse of that causing the day-light solar-diurnal variation."*

At the time the above report was made the thought was expressed that these observations should be repeated whenever an eclipse offered an opportunity. Also, that the results of the 1918 eclipse were convincing, yet much additional information is needed in our attempt to solve the problem of terrestrial magnetism, atmospheric electricity and their relation to, say, the northern lights.

The eclipse of January 24, 1925, furnished the first near at hand opportunity for further observations. This eclipse, as is well remembered, swept across the northeastern section of North America. The totality portion of the eclipse became visible at dawn in Ontario and extended across New York state and Connecticut and out on the Atlantic. The number of stations engaged in making magnetic observations was comparatively few; most observatories were concerned in photographing the corona. Professor A. P. Carman, head of the Department of Physics, University of Illinois, suggested the desirability of again making declination observations, similar to those in 1918,—the position of *Urbana, Illinois,* being about the same distance from the path of totality except that this year the path swept by on the northeast, while in 1918 it was on the southwest.

Fortunately, in preparing for the observations the same magnetometer and accessory apparatus were found that were used in the eclipse of 1918. The magnetometer needle stood suspended by a single silk fiber all this while and hence the suspension exhibited no twist—the zero would remain fixed, absolutely, over a period of at least 24 hours. Two magnetometers were set up, but in this report reference will be made to the data of but one (magnetometer No. 1). The apparatus was set up in a small astronomical observatory on the south campus about one-half mile south of the auditorium. The telescope of the observatory with its heavy iron base had

been removed for repairs and the concrete pedestal was used as the support for the magnetometers. Every precaution was taken not to move the position of magnetic materials. Even the observers remained quietly at their respective posts. This station is located about 1000 feet southeast of the 1917 magnetic station established by Wm. W. Merrymon of the Coast and Geodetic Survey. It is about ½ mile east of the Illinois Central Railroad, and about 1/5 mile east of the new stadium. The interurban tracks are about 1 mile to the north. From preliminary observations the magnetometer deflections were not disturbed, other than jarring the needle due to mechanical disturbances transmitted through the ground, by the passing of trains or by automobiles on nearby roads; however the starting and throwing off of the power on the interurbans did have an effect.

The observations were taken at *one minute* intervals from a little after five in the morning until eleven. The first run was made on the day of the eclipse (Saturday, January 24, 1925) and a standardizing run was made on

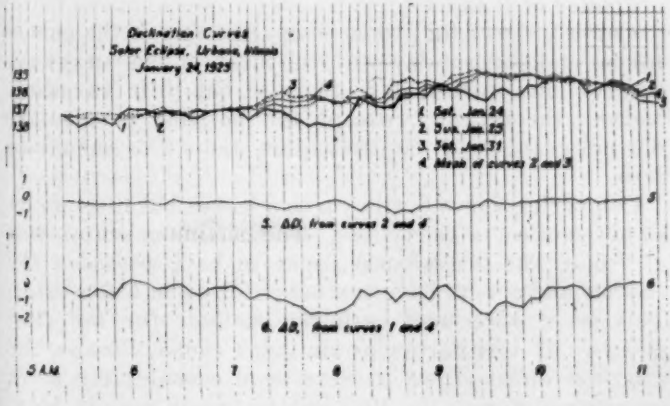


FIG. I.

the following forenoon (Sunday), and again on the following Saturday morning (January 31). The day following the eclipse was considered an *undisturbed* day since the moon passed the sun by 13°. The time (G. M.

T.) was from the observatory clock. A complete log was kept throughout the six hours over which the readings were taken. In reducing the data the deflections in millimeters were plotted against the time in hours. This gave three curves (see Fig. 1), No. 2 for Sunday; No. 3 for the Saturday following; and No. 1 for the eclipse data. Curves 2 and 3 are shown superposed, and the mean, No. 4, drawn. It should be noticed that curves 2 and 3 even though taken six days apart are very similar. It was thought for this reason that a mean curve would represent the undisturbed day with a minimum amount of error. The data for the eclipse curve (No. 1) were next set down on top of 2, 3, and 4. It is evident that new disturbing factors were present in this curve. Some of these may have been due to local disurbances, though not likely to the extent indicated.

It is usual to plot the difference, ΔD, between the ordinates of the eclipse curve and the undisturbed curve. Proceeding thus results in curve 6.

For the purpose of further comparison another curve (5) was plotted in which ΔD is the difference in the ordinates of 2 and 4.

Curve 5 shows that when comparing one of the curves for an undisturbed day with the mean of the curves for the two undisturbed days there is but little variation. Indeed, theoretically, except for possible progressive diurnal changes in the declination, the ΔD's should be zero.

Comparing curve 6 with curve 5 leaves but little doubt as to the effect of the eclipse. The maximum eclipse was at 7:55. The disturbance seems to have *preceded the shadow* and also to have *continued for some hours after.* This is in *agreement with the findings for the 1918 eclipse.* At this particular station, *Urbana, Illinois,* the magnetic effect seems to have been considerably more pronounced during the 1925 eclipse than it was in 1918.

The data herewith submitted *corroborates* conclusions (a) and (b) of Dr. Bauer's report on the 1918 solar eclipse.

The writer was ably assisted by L. P. Garner and A. D. Hummell, graduate students in electrical engineering and in physics respectively, and by A. J. McMaster, a senior in General Engineering Physics.

Laboratory of Physics,
University of Illinois
February 18, 1925.

PAPERS ON GEOGRAPHY AND GEOLOGY

THE PANAMA GATEWAY AS RELATED TO THE INTERCONTINENTAL TRADE OF SOUTH AMERICA

W. O. Blanchard, University of Illinois

Panama, a Commercial Barrier.

Geologically, the Isthmus of Panama was the tie that bound the two continents. Commercially, its importance lay in the fact that it separated the two oceans and per se formed an obstacle to ocean trade. In the four hundred years since its discovery it has never functioned as a link in land routes, but always as a barrier to water-bourne commerce. In comparison with the long and costly detour about South America, however, the Panama barrier possessed certain commercial advantage which at various periods of its history made it an extremely important trade route.

Panama of Interest only to Western South America.

In its relation to South American commerce Panama has been of importance only to the Pacific hinterland of that continent. The reason for this is to be found in the influence of both geographic and economic factors. Differences in the stage of economic development and, to a minor extent, contrasted resources have made the countries of the North Atlantic basin the complementary commercial region for South America. Of the total foreign trade of the latter, over 75% is normally with western Europe and eastern United States. Furthermore, there is little transcontinental trade overland. The Andes constitute a commercial as well as a drainage divide. As a result the foreign trade routes of South America are north-south routes, those of the Atlantic portion moving directly via the Atlantic and those of the Pacific via either Panama or Magellan. Our inquiry is thus limited to a study of the trade between Pacific South America and the North Atlantic via Panama.

Pacific South America.

Conditions within Pacific South America help to explain the character and quantity of its foreign trade as well as the choice of routes over which this trade moves. Politically, the region includes all of Chile and parts of Bolivia, Peru, Ecuador, and Columbia, an area approximately 1,086,000 square miles with a present population estimated at 12,231,000 people, of which certainly one-half and probably three-fourths, are Indians or Mestizos. Aridity and rough topography have greatly restricted the area of cultivable land, agricultural commodities making up only 18% of the total exports.[1] The Andes are, however, highly mineralized and the products of the mines make up the great bulk of outgoing commodities. All parts of this long narrow belt, which we have termed Pacific South America, are not equally productive. Since Panama and Magellan lie at the two extremities the location of the important centers of shipping is important as affecting the competition of the two routes. The southern half of Chile—some 1,500 miles—is productive of relatively small tonnage. However, this is counterbalanced by the great shipping activity of the northern half of the country—50% greater than all the rest of the Pacific coast of South America. The geographical center of the whole belt, therefore, coincides approximately with the economic center of gravity, and Antofagasta in the nitrate fields may be regarded as that center.

Periods of Isthmian Traffic.

With respect to the commercial carrier the history of Isthmian transit trade divides itself naturally into three periods: that of the pack mule, the railroad, and the canal.

THE PACK MULE PERIOD

The Camino Real.

For over three hundred years trans-isthmian traffic depended upon the pack mule for a carrier, precious

11919-20-21.

Fig. 1.

A Glimpse of the Royal Road.

Fig. 3. From Gause, F. A. and Carr, C. C. The Story of Panama, Silver Burdett, and Co., N. Y.

metals formed the principal cargo and a mule path through the jungle was the highway. Fig. 2 shows the relative positions of the various routes. The trail was a disgrace even for a mule and during the rainy season it was practically impassable. (See Fig. 3.) After 1534 the Rio Chagres was improved sufficiently to allow light draft barges to ascend to Cruces and thus supplement

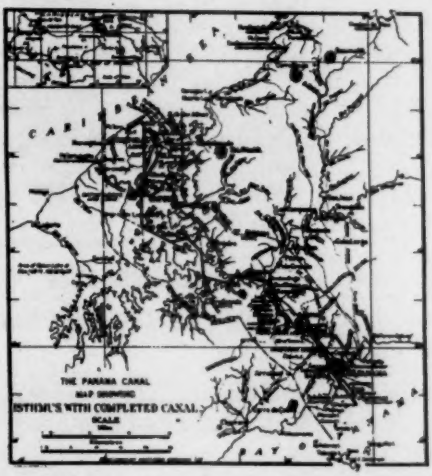


Fig. 2. From Official Handbook of the Panama Canal, Washington, D. C., 1915.

the Atlantic portion of the overland route. (Fig. 4.) Likewise the terminal ports were squalid tropic villages wedged in between the sea and the jungle. Porto Bello, especially, with its heavy rainfall and malarial swampy coast was shunned by all the Europeans except for the brief interval when the annual fair was in progress. Panama at the Pacific terminus enjoyed a somewhat better climate and became the entrepot for the whole Pacific coast. Both villages were commercial communities pure and simple. Their sole raison d'etre was the transit trade, and they flourished and declined with the ebb and flow of commerce through their gates. The remnants of some of these towns are shown in Fig. 5. Lorenzo was the fort at the mouth of the Chagres; Nombre de Dios was the original Atlantic terminus of the overland trail.

The deleterious effects of the climate as well as the danger of pirates was reduced to a minimum by confining the actual transfer of goods over the Isthmus to a period of only 40-50 days and by timing the galleon movement from Spain so as to have transit movement and the fair at Porto Bello occur during the winter dry season.

Bad as it was the Isthmian route was preferable to the long stormy journey about the Horn. When the flow of precious metals, which had motivated the trade and had warranted the construction and maintenance of the Camino Real, declined, the Isthmian shipping languished and by 1750 was of little importance. Meanwhile the improvements in ship construction[2] and the increase in knowledge of the southern route led to considerable traffic via the Horn. For the century, 1750 to 1850, the latter path was the route most used.

THE RAILROAD ERA—1855-1914

Panama Railroad Built Chiefly for United States Intercoastal Trade.

To the builders of the Panama Railroad the chief hope for returns lay in the United States intercoastal trade. South American commerce was regarded as secondary. That this opinion was justified is indicated by Fig. 6, which shows the total Isthmian traffic for the last twenty years of the railroad period together with that portion going to or from western South America. It will be seen that this latter never amounted to one-half the total. In 1912, after almost a half century of operation, the railroad's total tonnage was equal to but 3% of the trade of Chile alone for that year. It will be seen from this that the supremacy of the Horn or Magellan route in the trade of western South America during the railroad era was never seriously threatened.

Why Magellan Remained Supreme.

The failure of the railroad to divert this trade from the southern route was due to a series of factors, partly

[2]Magellan's largest boat was of 150 tons while at Callao in 1789 there were 32 ships, one of 1800 tons and the smallest of 123 tons.

Ascending the Chagres River

Fig. 4. From Anderson, C. L. G., Old Panama and Castilla del Oro, Page Co., Boston, 1911.

Fig. 5. From Gause, F. A. and Carr, C. C. The Story of Panama, Silver Burdett and Co., N. Y.

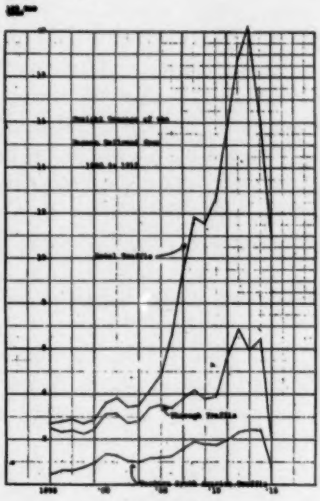


Fig. 6.

geographic, partly human. The trade of western South America was primarily with Europe rather than with the United States so that the saving in distance via Panama was not extremely large.[3] Again, the railroad enjoyed a monopoly of the transit trade and used its privilege to exact high rates for passengers and freight.[4] Furthermore, its service was usually the basis for much complaint. In addition to excessive charges there were costly delays, damages to goods, poor connections with boats, frequent theft of goods and inadequate facilities generally.

Freights via Panama were adjusted to meet the competition of Magellan. Thus in 1905, 100 pounds of general merchandise from New York to Buenaventura paid 75 cents; to Valpariso, only 50 cents. Thus the latter,

[3]Even for the United States, exports to the west coast in 1907 via Panama were $7,000,000, but via Magellan more than twice that.

[4]The Panama Railways published tariff gives the following rates for the transit (47¾ miles) :—

Passenger $25.00.
Excess baggage, over 50 pounds, 5c per pound.
Coal, $5.00 per long ton.
Cattle, $5.00 to $7.00 each.
Copper or tin ores in bags ¾c per pound.
Lumber, $10.00 to $15.00 per M.
Gold, ¼% of its value.
Silver, ⅛% of its value.

though 3,000 miles farther south, enjoyed a rate 25 cents lower. In spite of these efforts the railroad did little business with western South America except at the extreme north. South of Callao it was negligible. The great bulky cargoes making up the major part of the exports of the west coast all went via Magellan. In 1884 Chile exported 550,000 tons of nitrate; in 1905, 1,603,140 tons. This tonnage was 26 and 30 times respectively the total west coast exports via Panama for those same years.[5]

Turned over to the United States with the French Panama Canal Concession in 1904, the railroad was described as the proverbial "right of way and two streaks of rust". Little had been done to increase its business or improve the property. The best that could be said of the road was that there had been no collision for some time, but as Stevens remarked, "A collision has its good points as well as its bad ones—it indicates there is something moving on the railroad." With the informal opening of the canal in 1914 the railroad ceased handling through commercial freight.

THE CANAL PERIOD

Primary Object of Canal Construction.

The chief object of the United States in taking over the canal project after the French had failed was to facilitate the intercoastal movement of our merchant[6] and naval vessels[7]. However, a careful study had indicated that the prospective tonnage of western South America which would use the waterway was large. In 1909-10 the reports of shipping showed that of 8 1/3 million net register tons of all traffic which could have used the canal had it then been in existence, almost one-half was traffic originating in or destined to western South America. That

[5]It must not be thought however that the Panama railroad did little business or was unprofitable to the stockholders. On the contrary, it was said to be carrying in 1914 more cargo per mile of track than any railroad in the world and it certainly ranked among the two or three most profitable railroads of its day. It was said to have earned $2,000,000 before completed. From 1853 to 1861 its dividend averaged 16%; from 1881 to 1905 it was almost 5%. In 1868 a single dividend of 44% was paid entirely from earnings.

[6]The time required for the intercoastal water journey via Magellan was about 6 months; via the Panama Railroad it was about 2 months; via the Panama Canal it was about two weeks.

[7]The voyage of the battleship Oregon from the Pacific coast around South America to join the Atlantic fleet during the Spanish-American War did much to awaken public sentiment to the necessity of waterway.

between Europe and western South America alone was estimated at 38% of the whole.[8]

Canal Traffic Compared with that of the Railroad.

In spite of the World War with its demoralization of ocean shipping[9] and of the slides which closed the canal at various intervals, the record of the first six months of canal operation indicated that at last the Isthmus route had come into its own. In that period the tonnage transited was more than twice that carried by the Panama Railroad in double that time. In March, 1914, the canal carried almost as much as the railroad had

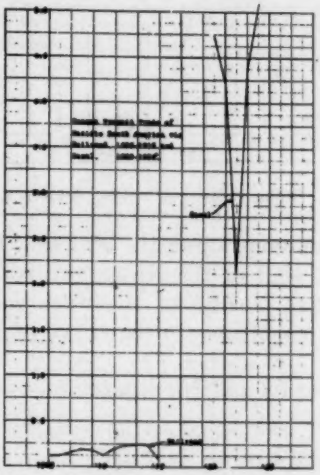


Fig. 7.

carried in an entire year. The busiest month (December, 1923) of the canal since its opening saw about four times as much tonnage transited as the Panama Railroad carried in the whole of the fiscal year, 1914.[10] The marked change which the canal opening had inaugurated in Isthmian transport is well shown in Fig. 7. Fig. 8 shows

[8]Johnson, E. R.—The Panama Canal and Commerce, p. 223., N. Y. Appleton, 1916.
It was estimated that the War reduced the canal tonnage by 50% the first year.

[9]Johnson, E. R.—The Panama Canal and Commerce, p. 223, N. Y. Appleton, 1916.

[10]In the 5 fiscal years, 1920-1924, the canal tonnage averaged 674,454 tons through commercial traffic. In the 5 years preceding the canal opening the railroad averaged about 3% of this amount.

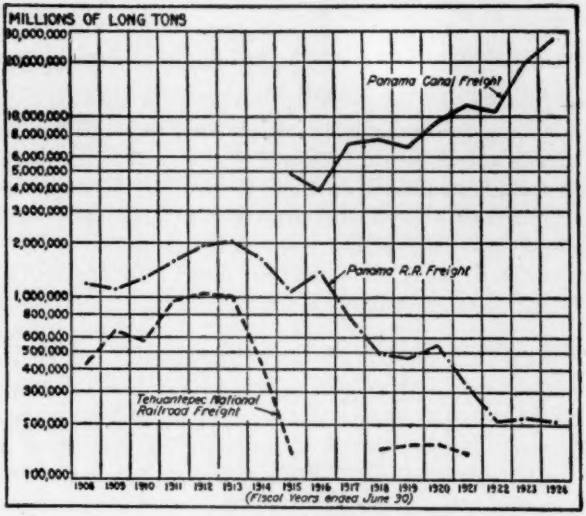


Fig. 8. From Commerce Report, October 6, 1924.

the effect of the canal upon the Panama Railroad traffic as well as upon that of the Nicaragua route. The effect of the temporary closing of the waterway by slides is reflected in the variations in the curve of railroad traffic.

Magellan Straits as a Rival Route.

Fig. 9 shows the number of vessels transiting the Canal, also those calling at Punta Arenas on their way through Magellan. The total number going via Panama in 1922 was twenty times that via the straits; furthermore, the latter were small vessels, mostly coasting steamers. The average for all was only 421 net tons each. The average for Panama ships up to date is about 4027 tons, or almost ten times as large.

A, Fig. 10, is more significant in that it shows the net tonnage moving by Magellan and by Panama between western South America and the North Atlantic. In 1923 the tonnage going via the Straits amounted to only 9% of the amount going via the canal.

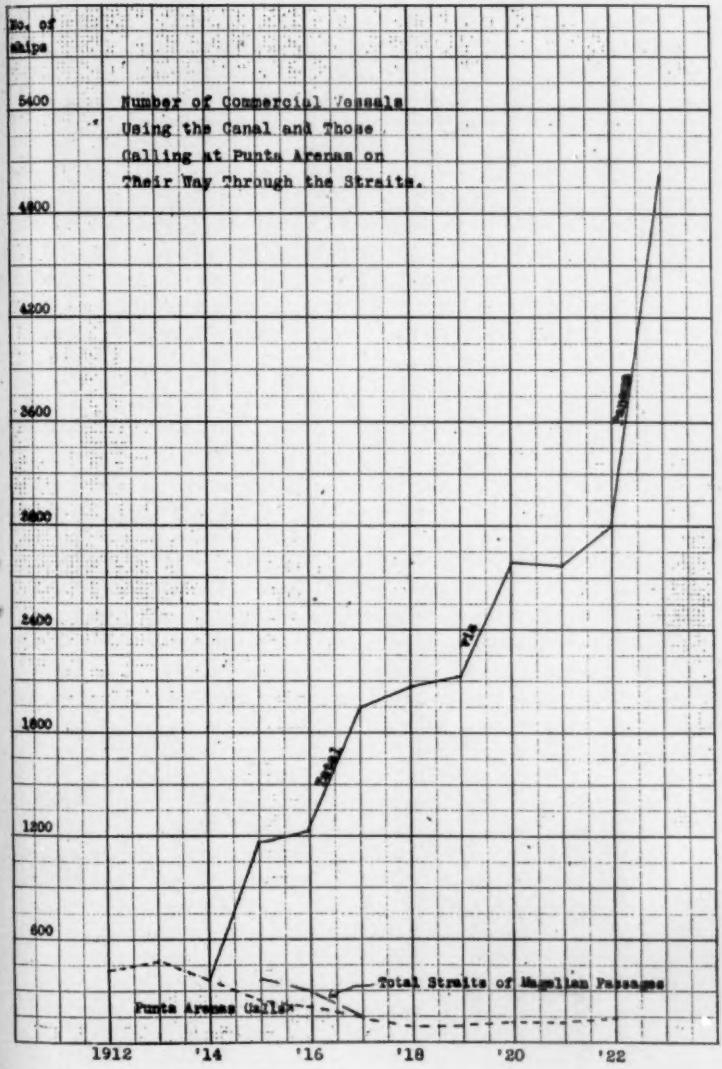

No. of ships
5400
4800
4200
3600
3000
2400
1800
1200
600
Number of Commercial Vessels
Using the Canal and Those
Calling at Punta Arenas on
Their Way Through the Straits.
Total
Total Straits of Magellan Passages
Punta Arenas Calls
1912
'14
'16
'18
'20
'22

Fig. 9.

Thousands of
Net tons.
400
800
1200
1600
2000
2400
2800
3200
Panama Canal
Straights of Magellan
Panama East Bound Tonnage
Panama West Bound Tonnage
Magellan East Bound Tonnage
Magellan West Bound Tonnage
Shipping between Western South America and the North Atlantic via Panama and Magellan* in 1925
*Based upon 4st ships' trips entering and clearing.
** Based upon data at Punta Arenas.

Fig. 10.

The greater savings effected by the canal for trade of the west coast with the United States as compared with the trade with Europe is shown by the predominance of European shipping in the Magellan route. An analysis of the Straits passages shows that the tonnage between western South America and Europe in 1923 amounted to seven times that between that coast and the United States.

B and C, Fig. 10, show the Straits and Canal shipping for 1923 analyzed as to direction of vessel movement. The explanation of the difference in the east and west bound tonnage in the case of Panama probably lies in the frequent tramps loaded with nitrate for the United States, which do not return via Panama. In the case of Magellan the preponderance of west bound traffic is due to the practice of two English lines in routing boats west via the Straits and back via Panama.

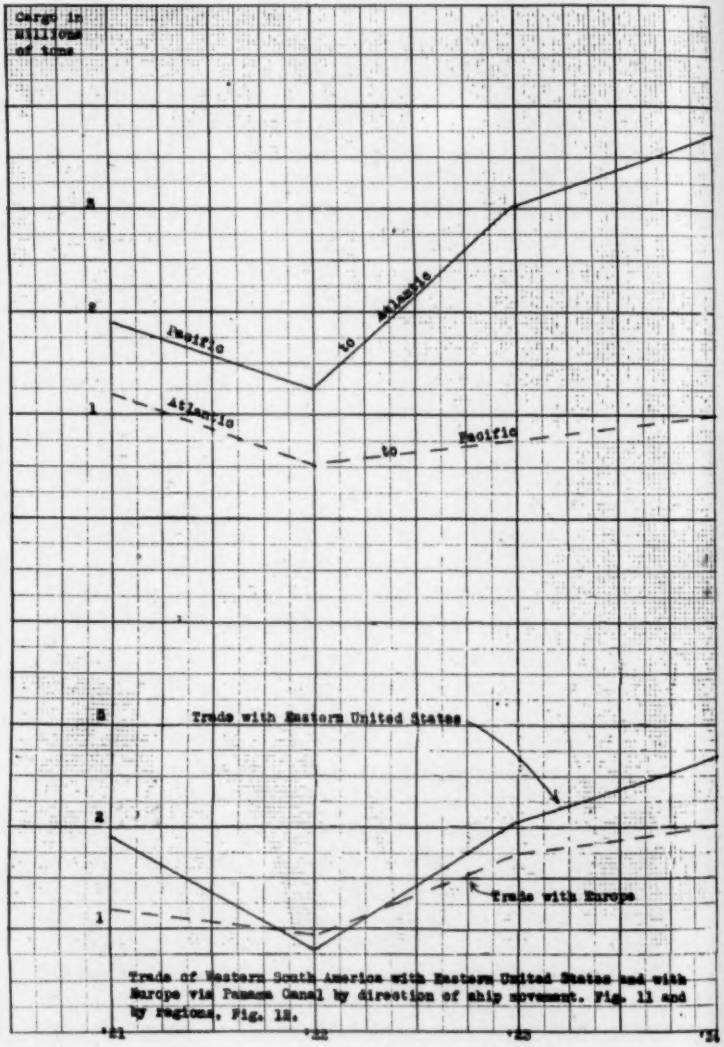
The Canal as a Factor in the Trade of Western South America.

The record of the traffic of western South America via Panama in the four year period, 1921-24, is shown graphically in Figs. 11 and 12. One must keep in mind the fact that though the War was over in 1918 the effects on shipping were still marked. This is particularly true of European commerce, a trade which has always been of great importance to South America.

Fig. 13 shows the Panama record of western South America as compared with the total transit tonnage. It will be noted that the recovery of the South American movement after the depression of 1922 was much more gradual than for the canal business in general. Petroleum movements from California to our east coast help to explain a goodly part of the great increase in total transits.

The importance of the various trade routes using Panama is shown by the Cartograph, Fig. 14. The north Atlantic-western South America route is seen to rank second to the United States intercoastal in importance.

The importance of the canal to various regions as



Trade of Western South America with Eastern United States and with Europe via Panama Canal by direction of ship movement. Fig. 11 and by Regions, Fig. 12.

Figs. 11 and 12.

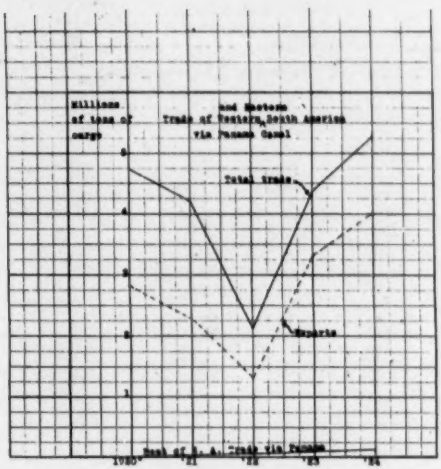


Fig. 13.

measured by their use of that waterway is shown in Fig. 15. Western South America is second only to our east and west coasts. Of all the Pacific or Atlantic traffic via Panama in 1923 western South America was the origin of 20.9%, and for the reverse movement the destination of 15.1%. Fig. 15 shows the record over a four year period.

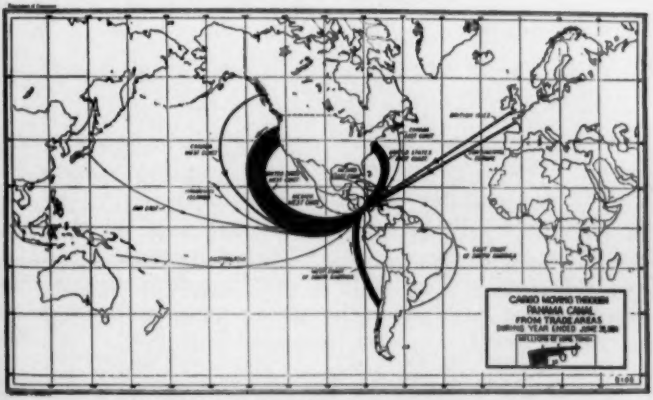


Fig. 14.

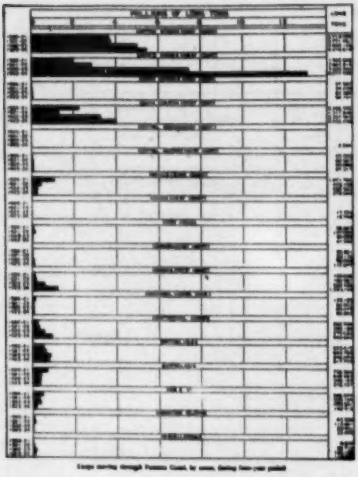


Fig. 15. From U. S. Commerce Report.

Fig. 16 shows the trade of western South America analyzed as to imports and exports. The latter tonnage runs from one and a half to four times the former. Extractive products, ores and agricultural raw materials, for the most part bulky and cheap, make full outgoing cargoes but manufactures require limited return space. Coal moving south is the only important exception and happens to be the largest single item going in that direction. Nitrate is the largest single export item of western South America.

Pre-Canal and Post-Canal Trade between the North Atlantic and Western South America.

In the ten years ending in 1899 trade between the United States and western South America increased 27%; in the next decade the increase was 158%. In the ten years from 1913 to 1923, nine years of which were during the canal regime, there was an increase of 163%. The latter growth in itself is not therefore remarkable except for the fact that in the same period our trade with the rest of South America increased only 95%.[11] Based

[11] It is interesting to note that during the same period our trade with the Pacific countries, with which the canal brought us closer, increased 233%; that with the rest of the world, by only 70%. Our Short Cut to the Pacific, Trade Record, National City Bank of New York, May 26, 1924.

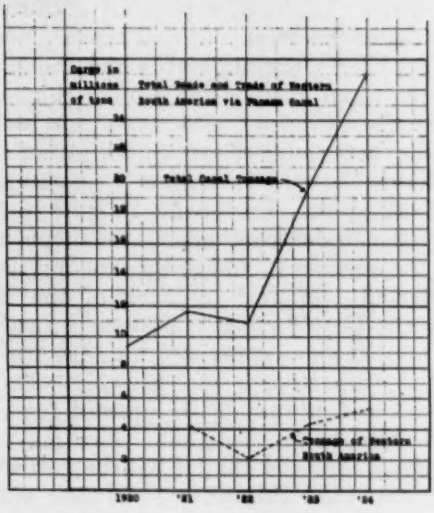


Fig. 16.

upon the net register tonnage of laden vessels in the trade there was an increase from 1914 to 1923 of about three-fourths of a million tons or about 50%. This includes commerce between Pacific ports of the two countries. It is significant that the bulk of this increase was in our imports, indicating that the Canal[12] has furnished a short cut for bulky west coast products to a market previously closed to them.

A record of net register tonnage passing between Europe and Western South America shows that from 1913 to 1923 there was a decrease of something less than a million tons, that is one-fifth or possibly one-fourth.[13]

Comparing the European losses with the gains of the United States in this decade, the one just about balances the other. An examination of Fig. 12 shows however that since 1922 trade with both the United States and Europe has been increasing. In general, we may conclude that in spite of the European debacle the canal minimized the loss otherwise inevitable to the west coast

[12]Military demands of the War played a part here also.
[13]Estimated by E. T. Chamberlain, Shipping of the West and East Coasts of South America, p. 16. It is based on records of the principal European countries.

shipping, and by 1923 had practically restored the ante-bellum status of the volume of that trade. The combined effect of a better economic status and the short cut offered by the canal enabled the United States to fill the gap left by the European withdrawal.

For trade between western South America and the North Atlantic the construction of the canal has been an epoch making event. The opening of the waterway has quickened the industrial life throughout the entire length of the west coast, and in the North Atlantic it has aided materially in shifting much of the trade from Europe to the United States. It was estimated that in 1923 the canal accounted for 80%[14] of the trade in question and the proportion is still growing. The War Department assures us that in its present form the canal will be able to care for the traffic which may develop in the next fifty years and that it will be entirely feasible then to increase the lock capacity. In view of these facts it would seem that the final triumph of Panama[15] over the Straits is essentially complete and permanent.

14Chamberlain, E. T. p. 7.

15Long, W. L.—Development of Panama Canal Traffic, Com. Reports, Wash. D. C., Oct. 8, 1924, pp. 13-16.

WILL THE ILLINOIS WATERWAY BENEFIT THE ILLINOIS COAL INDUSTRY?

ESTHER UTZIG, UNIVERSITY OF ILLINOIS

Some definite progress has been made on the Illinois Waterway which will connect the Illinois River with Lake Michigan. Eventually, it will connect two of the world's greatest inland waterway systems, the Mississippi System and the Great Lakes-St. Lawrence System. It is properly called the Great Inland Waterway System.

The section of this waterway which concerns Illinois will occupy the Des Plaines and Illinois Rivers between Lockport and La Salle, Illinois, a distance of approximately 63 miles. Five locks and dams which will generate 60,000 horse power are to be constructed at the following points: first, Lockport; second, Brandon Road, the southwest limits of Joliet; third, Dresden Island, below the mouth of the Kankakee River; fourth, Belle Island, two miles east of Marseilles; and fifth, Starved Rock.

From Starved Rock to La Salle, the Illinois River will be dredged to an eight foot depth, and it is expected the present seven foot depth of the Illinois River will be dredged to a depth of eight or nine feet between La-Salle and the Mississippi River by the Federal government. The present locks and dams in the Illinois River will be removed since they will not be needed, provided the present diversion into the Chicago Drainage Canal of 10,000 cubic feet of water per second from Lake Michigan for sanitary purposes is continued.

The question arises, "What will the Illinois Waterway do for the state to justify this expense of $20,000,000?"

Of the numerous commodities which will be affected by the Waterway as a means of transportation, the only one we are interested in here is the reported benefits of the Waterway to the cheap transportation of Illinois coal. Let us investigate the trend of coal production in Illinois and estimate approximately the amount of coal which will be available for transportation by the Illinois Waterway.

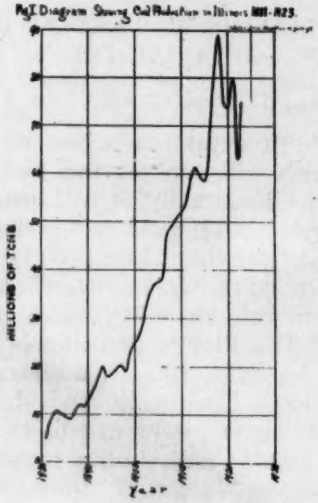


Fig. 1.

Continuous records of Illinois coal production for fiscal years ending in June, from 1881 to 1923 inclusive, are available. These show (Fig. 1) that a maximum increase in production was attained in 1918 during the war period, and the anticipated reaction came in 1919 following the armistice. The Illinois coal miners' strike of 1922 accounts for the low point of production in the state during the last decade.

Illinois produces twice as much coal as she uses, and of this consumption, four-fifths is Illinois coal. No other coal-producing state consumes so large a portion of its annual production essentially within its own borders and exports so small a proportion.[1]

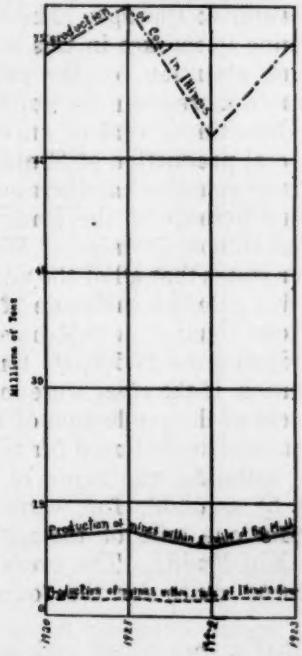
In 1923, only 16,655 tons of coal from the Lancaster Mine in Peoria County, situated three-fourths mile from the Illinois River, was shipped by boat; the rest of the production used the railroads for transportation.[2] The Lancaster Coal Company uses the Illinois River for two reasons. One is that they have no rail connections closer than four miles and the other is that their business is that of supplying steam boats, dredges, the pumping

1O. H. Barrett; Mineral Resources in Illinois.
2Illinois Annual Coal Report, 1923, p. 60.

plants of drainage districts, and towns that have no rail connections.[3]

When the Waterway is completed, how much coal will be directly available for water transportation on the main Waterway? No definite figures are available to indicate how much coal will be shipped over the proposed Illinois Waterway.[4] Although we cannot know the production of mines along the Waterway in the future, nevertheless, we can form some estimate of the amount available in the future, by getting the total of the present production of every mine within a short distance, let us say one mile, of the Waterway.

Fig. II Production of Illinois Coal Compared with Production of mines one mile from main channel of Illinois River and Big Muddy System



The accompanying graph (Fig. II) shows the total production of these coal mines within one mile of the

[3]Letter received from Lancaster Coal Co., Feb. 5, 1925.
[4]Letter from R. W. Putnam, Major Corps of U. S. Engineers, Feb. 5, 1925.

Illinois River, compared to the total production of Illinois coal for the same years. The average production of all these mines is 1,500,000 tons. As can readily be seen, this amount directly available for water transportation on the Illinois Waterway is insignificant, however, in comparison to the average annual production in Illinois. It does not seem probable that any of the large coal fields in southern Illinois will benefit by cheap water transportation which the Waterway in its present proposed form will afford.

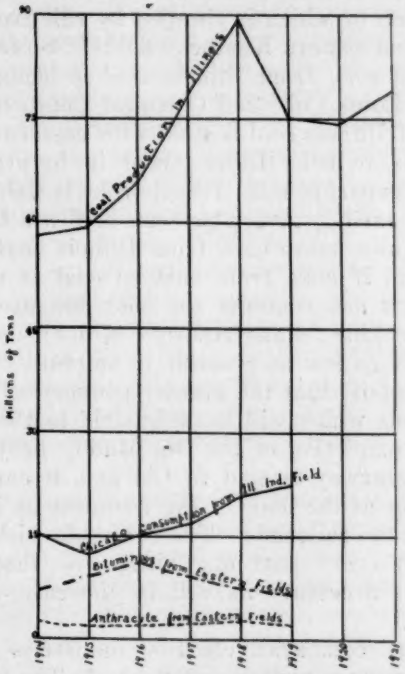
Mr. William L. Sackett, late superintendent of the Division of Waterways of the State of Illinois, has made a report recommending the development of the Big Muddy River in southern Illinois as a means of opening up coal fields of this section and permitting transportation of coal by water to Chicago. The problem of moving coal from mine to market in this area has been receiving increasing attention for the past sixteen years because of the rapid increase in the number of mines and their output of bituminous coal of an excellent quality. Since 1910, the total production of Franklin, Williamson, Jackson, and Perry counties has increased from twenty-one to thirty-four percent of the state output in 1923. The report of the Illinois Division of Waterways on the Big Muddy River states that all of the mines within a belt ten miles wide, five miles on each side of the Big Muddy River in these four counties, would have practically all of the 1921 production of 17,500,000 tons available for water transportation, if the river were improved. This is twenty-one per cent of the production of Illinois for 1921.

By the same method as that used for the Illinois River, an approximate estimate was made of the amount of coal which will be available for water transportation from mines within one mile of the main channel and branches of the Big Muddy. The average total annual production of these mines for the four-year period is 10,000,000 tons.

Thus we see that a very rough estimate of 11,500,000 tons may be made for the amount of coal produced near the Illinois and Big Muddy Projects.

Chicago is unquestionably the largest consumer of Illinois coal, which has access to the Waterway[5], consuming approximately twenty-three per cent of the total average production of coal in Illinois. The graph (Fig. III) shows the sources of Chicago consumption from

Fig. III Production of Illinois Coal and Sources of Chicago Consumption 1914-1922


Coal Production in Illinois
Millions of Tons
Chicago Consumption from Ill. Ind. Field
Bituminous from Eastern Fields
Anthracite from Eastern Fields

1914 to 1919 inclusive. The curve of consumption of anthracite coal has remained practically on the same level, while the curve of bituminous from the Illinois-Indiana field shows an increasing consumption.

If Chicago's consumption of coal from Illinois is increasing, that does not necessarily mean all the coal will be transported to Chicago by means of the Waterway, since, as I have tried to show, the total production of mines near the Waterway and Big Muddy is approxi-

[5]Letter from Major R. W. Putnam, Major Corps of Engineers, War. Dept. Feb. 5, 1925.

mately 11,500,000 tons, while Chicago's consumption is over 16,000,000 tons of Illinois coal.[6]

It does not appear likely that Chicago will greatly increase her consumption of Illinois coal in comparison with that from eastern fields since it is of a poor grade not suited to coking purposes. The Chicago By-Products Coke Company consumes 720,000 tons of coal annually, all of which is shipped by rail from the West Virginia and eastern Kentucky fields.[7] So far as known, commercial coke from Illinois coal is being made only at the St. Louis Coke and Chemical Company, where 80 per cent of Illinois coal is used with eastern coal.[8]

Attempts to coke Illinois coal in by-products oven have been experimental. Illinois coke is light, and tends to shatter easily. Available tests indicate that for any given purpose, more coke from Illinois coal will be required than if coke from eastern coal is used. High sulphur and ash contents set back the use of Illinois coals for coking; manufacturers of both coke and gas desire coals as low as possible in sulphur.

If we suppose that the greater proportion of this coal from Illinois which will be accessible to the Waterway after the completion of the Big Muddy project and the Illinois Waterway is sent to Chicago, it cannot be unloaded right at the door of the factories as it can when shipped on the railroads. The railroads with their spur lines go to every part of Chicago, so that no transshipment is necessary as will be the case with water-borne coal.

There are comparatively few industries located on rivers or present existing waterways.[9] The Chicago By-Products Coke Company, located on the Drainage Canal and South Crawford Avenue, one of the large consumers of coal in Chicago, was not located on the Drainage Canal because it would have easy access to water-borne coal, but because the Canal supplied the large amount of water necessary in the manufacture of gas.[10]

[6] Dr. R. C. Honnold, Sources of Chicago's Coal Consumption.
[7] Interview with G. F. Mitchell, Vice-Pres. Peoples Gas, Light & Coke Co., Chicago.
[8] Interview with Prof. S. W. Parr, University of Illinois.
[9] Letter from Dr. R. C. Honnold, Nov. 19, 1924.
[10] Interview with G. F. Mitchell, Vice Pres. Peoples Gas, Light & Coke Co., Chicago.

Any handling of coal means breakage. To get from a mine, by rail to a given waterway, to again unload from the boat into a railroad car for movement to ultimate destination would mean the development of a great deal of breakage and consequent degradation of such coal.

Chicago has no facilities for unloading and storing waterborne traffic. The entire water front from Calumet Harbor on the south to the northern limits of the city has now been given over to park projects. The Chicago and Northwestern Railroad has one spur track running over to within 1,000 feet of the pier, but the cost of haul by truck from the pier to the commercial center of Chicago is so great that the pier will never be of use as a Chicago terminal, unless connected up to railroads.

The Chicago River from Chicago Avenue on the north to 22nd Street on the south is now seventy-five per cent owned and controlled by railroads. The other twenty-five per cent is occupied largely by industries.[11] The portion south of 22nd Street is being filled and taken away from the water interests as rapidly as possible. The South and West Forks of the South Branch of the Chicago River were abandoned by acts of Congress in 1923.

The only places available for handling of freight after having used the lake front for park purposes, and the Chicago River for railroad and private industries, is a place south of Chicago known as the Calumet or Lake George district. The work cannot be done for a few thousands; it will cost the State of New York over $25,000,000 for their terminals on the New York State Barge Canal and it is going to cost Chicago and Illinois a large sum.

A climatic factor which is disadvantageous to the Waterway is the freezing during the winter months. It is said that on the average, the river will remain closed from Christmas to Inauguration Day, a total of 70 days.[12]

The percentage of the coal tonnage produced each month for a ten year average, 1914 to 1923, is shown

[11] Putnam, Maj. R. W., J. W. Soc. Eng. S '23, Chicago's Need for a Comprehensive Water Terminal.
[12] Cooley, L. E., Ice on the Illinois Waterway.

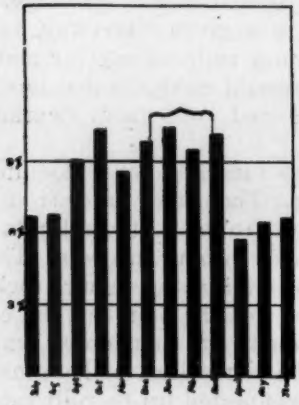


Fig. 4.

in the graph (Fig. IV)[13]. The two highest producing months are October and January, the latter being one of the months during which the Waterway is closed by ice.

No matter how many canals were built from mines to the Waterway, coal produced from the end of December to the beginning of March would have to seek rail transportation, or the production during the ice-free months would have to be increased to care for the normal winter production in order to ship all coal to points of consumption for shortage before ice closed the Waterway. The mines would be idle during the winter months unless coal were stored at the mines. It isn't possible that there will be no demand for coal production during these months, since all users, domestic and commercial, will not have an adequate supply of coal on hand to last for the season.

The circumstances and conditions of coal production in Illinois do not as yet permit the beneficial use of any Waterway now in prospect within the state for coal haulage. The amount of coal which is produced in mines near the Illinois and Big Muddy rivers is small in comparison to the total coal produced in Illinois. Thus we can conclude that the rest of the coal in Illinois can only

[13]Illinois Annual Coal Report, 1923.

be transported over the Waterway by the added expense of building spur canals to mines, or using rail haulage from mine to the river, which means development of a great deal of breakage and degradation of coal.

Dr. R. C. Honnold of the Honnold Coal Bureau at Chicago sums up the situation when he says: "When our present waterways as well as, let us hope, the St. Lawrence Waterway, shall be developed, and as a result we shall have an increasing number of our manufacturing and other industrial enterprises located near present canals and rivers, and there shall, as a result, have been developed a substantial movement of freight that is not seriously damaged by repeated handling, it will then be time to consider the development of canals to coal fields for the purpose of providing the loading of Illinois coal directly from tipples onto barges and its entire movement from mine to factory by water."[14]

[14]Letter from Dr. R. C. Honnold, Nov. 19, 1924.

THE DEVONIAN STRATA OF THE ALTO PASS QUADRANGLE

CHARLES FERNANDO BASSETT, UNIVERSITY OF ILLINOIS

Acknowledgment.

The material used in this paper was collected during the summer of 1923 by Professor T. E. Savage and the writer for the State Geological Survey report on the Alto Pass quadrangle. Many thanks are due Professor Savage for helpful suggestions made in the working up of this material and for permission to publish this paper.

Location of the Alto Pass quadrangle.

The Alto Pass quadrangle is located in the southwestern part of the state bordering the Mississippi River, and includes parts of both Jackson and Union counties, as shown in Fig. I.

Location of the Devonian area.

The area of Devonian rocks covers about 40 square miles in the southwest portion of the quadrangle. These rocks extend from Wolf Lake north to Rattlesnake Ferry, forming the east bluff of the Mississippi River valley. From Rattlesnake Ferry southeast to about a mile northeast of the Gregory school the area is bounded on the north by a fault-plane which brings the middle Devonian in contact with the upper Mississippian rocks. From Gregory school southeast to Walnut Grove church, and thence south to the edge of the quadrangle, the upper Devonian strata dip regularly eastward beneath lower Mississippian strata.

Structure.

In general the formations dip gently eastward at an angle of 3 to 4 degrees, which varies locally. The strata are gently undulating from north to south. In addition to the large fault bordering the Devonian area at the north, there are many small faults in this area, only a few of which can be shown on the map.

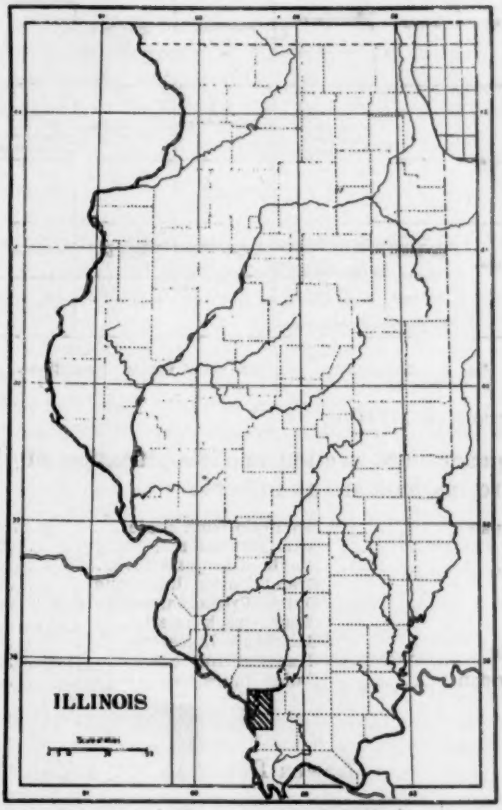


Fig. 1. Map showing the location of the Alto Pass quadrangle.

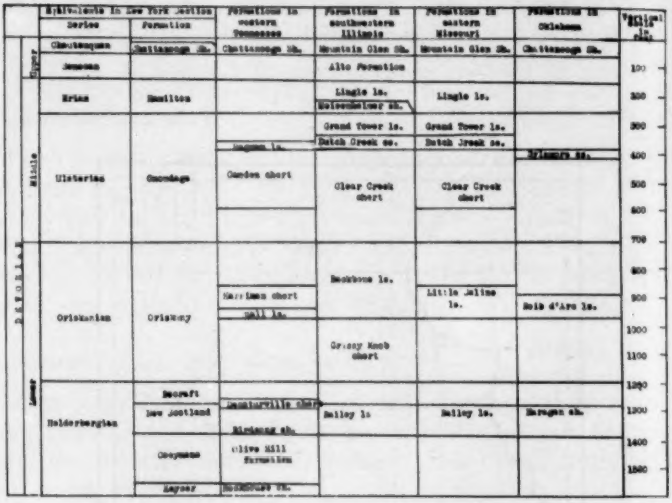


Fig. 2. Comparative sections of Devonian formations.

The Devonian section.

The generalized section and classification of the Devonian formations are as follows:

Chautauquan	Mountain Glen shale	20- 40 ft.
Senecan	Alto formation	80±
Erian	Lingle limestone	75- 90±
Ulsterian	Grand Tower limestone	60- 75
	Dutch Creek sandstone	6- 10
	Clear Creek chert	300±
Oriskanian	Backbone limestone	250±
	Grassy Knob chert	200±
Helderbergian	Bailey limestone	160
		1205±

Lower Devonian

HELDERBERGIAN SERIES

Bailey limestone.

The Bailey limestone is a dark gray, fine-grained, cherty and shaly limestone which occurs in thin, irregular layers, 2 to 8 inches thick, interbedded with somewhat thinner layers of chert.

This limestone is exposed almost continuously in the bluff of the Mississippi River, from Wolf Lake north to Rattlesnake Ferry, to an average height of 80 feet, but, due to the undulating character of the strata, it reaches a maximum height of 160 feet in a few places. In common with the other Devonian formations, these strata generally dip eastward at an angle of 3 to 4 degrees, except immediately south of Rattlesnake Ferry where the rocks are inclined 19 degrees due north as a result of the down drag on the south or upthrow side of the fault plane.

Correlation.

The Bailey limestone of Illinois is the equivalent of the Bailey limestone in Missouri, and corresponds in age to some part of the New Scotland formation of the New York section[1]. This is indicated by the presence of such fossil species as *Chonostrophia helderbergia, Dalmanella perelegans,* and *Leptaenisca concava.* This limestone can also be correlated with the Birdsong shale of Tennessee and with the Haragan shale of Oklahoma on the basis of its fossil content.

ORISKANIAN SERIES

Grassy Knob Chert.

The Grassy Knob Chert was named by T. E. Savage from the Grassy Knob exposure near Rattlesnake Ferry. This chert may be seen resting unconformably on the Bailey limestone in the Mississippi river bluff south of Rattlesnake Ferry, where it dips 19 degrees north above the Bailey limestone. The thickness of this chert formation is almost 225 feet. It consists of very rough-surfaced, hackley, thick-bedded, gray to reddish-brown chert, in layers 12 to 48 inches thick, the layers becoming thinner towards the top where they change to rather even bedded, whitish, iron-stained layers, 4 to 8 inches thick. The Grassy Knob chert has been recognized at no place in Illinois outside the Alto Pass quadrangle.

[1]Savage, T. E. Am. Jour. Sci., Vol. XLIX, p. 173, March, 1920.

Correlation.

Only three species of fossils have been recognized from this chert, namely, *Anoplotheca flabellites, Orthotetes pandora,* and *Spirifer murchisoni.* None of these is definitely diagnostic of Oriskany age. However, since none of these species occurs in rocks older than the Oriskany, and since rocks of undoubted Oriskany age immediately overlie the chert from which they came, the Oriskany age of the chert is thus indirectly established. This chert seems to be closely allied to the overlying Backbone (Oriskany) limestone into which it passes by a rather gradual transition. There is no chert horizon of Oriskany age underlying the calcareous beds containing *Spirifer arenosus* either in western Tennessee or in Ste. Genevieve county, Missouri; hence this chert can not be directly correlated with any strata in either the Tennessee or Missouri localities.

Backbone Limestone.

The Backbone limestone is usually a rather coarse-grained, light gray to white, sub-crystalline limestone in layers ranging in thickness from 1 to 6 inches up to more massive layers nearly 15 feet thick. In the middle part the thin limestone layers alternate with thin, irregular bands of chert, 1 to 4 inches thick, which make the rock resemble the Bailey limestone, except that the Backbone limestone is generally white, less shaly, and more crystalline. Exposures of the Backbone (Oriskany) limestone are not known in the state outside of this area.

The Backbone limestone lies conformably on the Grassy Knob chert as in seen in exposures along the northwest branch of Hudgen's Creek, where the chert passes upward into a thin-bedded sandy limestone with chert bands in the lower part, as shown in Figure 3.

Correlation.

The fossils of the Backbone limestone are very large and abundant only in the lower massive layers a short distance above the chert. They become very scarce and

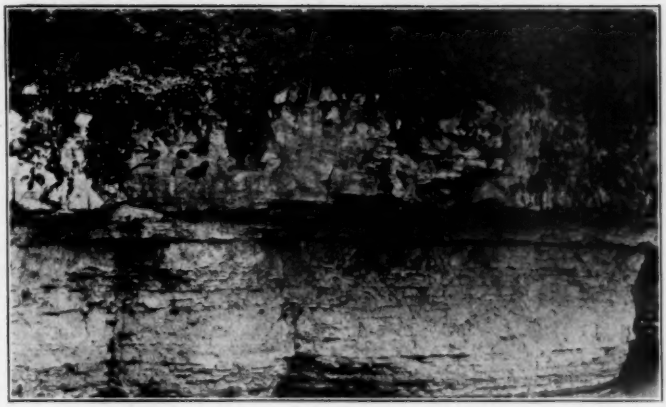


Fig. 3. Exposure of massive Backbone (Oriskany) limestone containing *Spirifer arenosus* overlying the thinner, sandy and cherty beds below.

mostly small in size thruout the greater part of the formation. This Backbone (Oriskany) limestone is the limestone which Savage[2] described from north of Grand Tower as apparently being related to the Becraft of the New York section. However, at that locality as at many other localitites in this area only the upper strata are exposed, and the typical Oriskany fossils are not present. Only a few small poorly preserved shells are usually obtainable from the upper portion of the formation. The fossils from the exposure on Hudgen's Creek and at Rattlesnake Ferry show that the Backbone limestone is of Oriskany age, and that it is the equivalent of the Little Saline limestone of St. Genevieve county, Missouri. The Backbone limestone corresponds to the Harriman chert and Quall limestone formations of Tennessee, and the Bois d'Arc limestone of Oklahoma. It also corresponds to the upper Oriskany strata of New York and Maryland, as shown by the presence in it of such fossils as *Beachia ovalis, B. suessana, Leptostrophia magnifica, Plethorhyncha barrandi, Rensselaria marylandica,* and *Spirifer arenosus.*

Middle Devonian

ULSTERIAN SERIES

Clear Creek Chert.

The Clear Creek chert occurs usually as a thin-bedded, slightly ironstained, gray chert. In places in the upper part there is a crystalline limestone alternating with chert layers, and in the lower part there usually occur layers of chert 10 to 12 inches or more thick. It is not uncommon to find lenses or layers of chert 2 to 6 inches thick interbedded with the limestone.

In the northwest portion of the Devonian area this chert rests unconformably on the Backbone (Oriskany) limestone. If the Grassy Knob chert is present in the southwest portion it has not been differentiated from the Clear Creek chert on account of the absence of the Backbone limestone between these chert formations, the lithologic similarity of the Clear Creek chert with the upper

[2]Op. cit., p. 173.

portion of the Grassy Knob chert, and the general absence of fossils.

Towards the top of Bald Knob, near the east side of this area, and at a considerably higher altitude than most of the exposures, the layers of chert become more massive, ranging from 18 to 48 inches thick. These layers are white and smooth like novaculite, and do not have the iron-stained appearance of the higher, thinner layers.

Correlation.

The Clear Creek chert has been placed by Savage[3] in the basal portion of the Onondaga of the New York section on the basis of its fossil content. The diagnostic species on which this correlation is based are *Chonostrophia reversa, Spirifer cf. divaricatus, S. duodendarius,* and *Dalmanites calypso.* This chert is the equivalent of the Clear Creek chert of Missouri[4] and has been correlated with the Camden chert of Tennessee[5]. The Sylamore sandstone of Oklahoma represents deposition of the same time as the Camden chert of Tennessee and hence is similar in age to the Clear Creek chert.

Dutch Creek Sandstone.

The Dutch Creek sandstone is a coarse grained, iron-stained, brown sandstone, loosely cemented in some places and firmly cemented in others. The formation reaches a maximum thickness of 10 feet in the Alto Pass quadrangle, but farther south in the Jonesboro quadrangle its thickness reaches 25 feet. It rests conformably on the Clear Creek chert as is seen in an outcrop in the Jonesboro quadrangle a short distance south of this area, where the sandstone and chert are interbedded.

Correlation.

In places the Dutch Creek sandstone is seen to grade up into the overlying Grand Tower limestone without an apparent sedimentary break. The stratigraphic

[3]Op. cit., p. 174.
[4]Op. cit., p. 174.
[5]Schuchert, Chas. Bul. Geol. Soc. Amer., vol. 33, p. 668, Nov. 2, 1922.

position of this sandstone and such species of fossils as *Spirifer duodendarius, S. macrothyris,* and *Odontocephalus aegeria* indicates the Onondagan age of the formation.

Grand Tower Limestone.

The Grand Tower limestone is a rather pure, granular to subcrystalline limestone, light to dark gray in color. It occurs in layers 3 to 6 inches thick, which rest conformably on the Dutch Creek sandstone. The latter in places passes upward with a gradual transition into the limestone.

Correlation.

The species of fossils named below clearly indicate this formation to be equivalent to the Grand Tower limestone of the Missouri section, and that it corresponds to the Onondaga limestone of New York: *Spirifer acuminatus, S. gregarius, S. macrothyris, S. segmentum, Stropheodonta patersoni, Odontocephalus aegeria.*

ERIAN SERIES.

Lingle Limestone.

The Lingle limestone is a hard, brittle, dark colored to black, coarse to fine grained limestone in layers 4 to 20 inches thick. It rests unconformably on the Grand Tower limestone. In places the Lingle limestone is somewhat shaly and is in thin layers which are light brown in color, and contain any shells of *Spirifer audaculus.*

Correlation.

The faunal content of this limestone proves that it corresponds to the Hamilton of the New York section, the following species being diagnostic of both formations: *Athyris spiriferoides, Chonetes coronatus, C. pusillus, C. vicinius, Spirifer audaculus, S. granulosus, Tropidoleptus carinatus,* and *Aviculopecten princeps.* The Lingle limestone is the equivalent also of the St. Laurent limestone of the Missouri section and of the Sellersburg formation of Indiana.

Upper Devonian

SENECAN SERIES

Alto Formation.

The Alto formation is a thin-bedded, rough, cherty and shaly, brown, silicious limestone which rests unconformably on the Lingle limestone.

Correlation.

This formation is thought to represent about the time of deposition of the Portage deposits of the New York section[6]. However, the fossil content is not diagnostic of any particular division of the upper Devonian, and no closer correlation is attempted. Some of the more common fossils are *Chonetes scitulus, Cryptonella eudora,* and *Leiorhynchus mesacostalis.*

CHAUTAUQUAN SERIES

Mountain Glen Shale.

The Mountain Glen shale is a hard, black, laminated shale, in which pyrite is common along the bedding planes and especially at the base. This formation is exposed in the same localities as the Alto formation on which it rests unconformably.

Correlation.

Savage[7] tentatively correlates this formation with the upper part of the New Albany black shale of Indiana and the Chattanooga black shale of Tennessee. The "Chattanooga" black shale of Oklahoma overlying the Sylamore sandstone may also be equivalent to this formation. It is recognized that this formation may properly belong in the basal Mississippian.

[6]Savage, T. E. Op. cit., p. 177.
[7]Op. cit., p. 177.

THE CHARACTER AND SIGNIFICANCE OF THE BASAL CONGLOMERATE OF THE PENNSYLVANIAN SYSTEM IN SOUTHERN ILLINOIS[1]

R. S. Poor, University of Illinois

Introduction:

Recent field study in the Alto Pass and Altenburg quadrangles in Union and Jackson counties, southern Illinois, has revealed a very interesting assemblage of transported fossils in the basal conglomerate of the Pottsville series (Pennsylvanian). These range in age from lower Silurian through upper Mississippian, thus affording a new chapter in the paleophysiography of this area.

Features of these beds to be considered in this paper are: (1) their areal distribution, (2) their structural and stratigraphic relations, (3) their lithologic character, (4) their fossil content, and (5) their bearing upon the geologic history of the region.

Areal distribution.

The best development of the conglomerate is 3½ miles north of Grand Tower, Illinois, on Fountain Bluff hill on the point between Trestle Hollow and the Mississippi River. It occurs here as a 20 to 30 foot mantle at an elevation of approximately 700 feet, and is exposed for about one-half mile to the north and east. Beyond this distance it is either absent or concealed. Elsewhere in the area the true conglomeratic phase is only locally well developed and usually as a fill in pre-Pennsylvanian valleys.

The southern limit of the Pottsville sandstone in the area forms an irregular line connecting Cobden, Alto Pass, and Rattlesnake Ferry. The Pennsylvanian strata is entirely on the down-throw side and north and east of the large fault separating the Devonian from the Mississippian. See Fig. I.

[1]Published with the permission of the Chief, Illinois State Geological Survey.

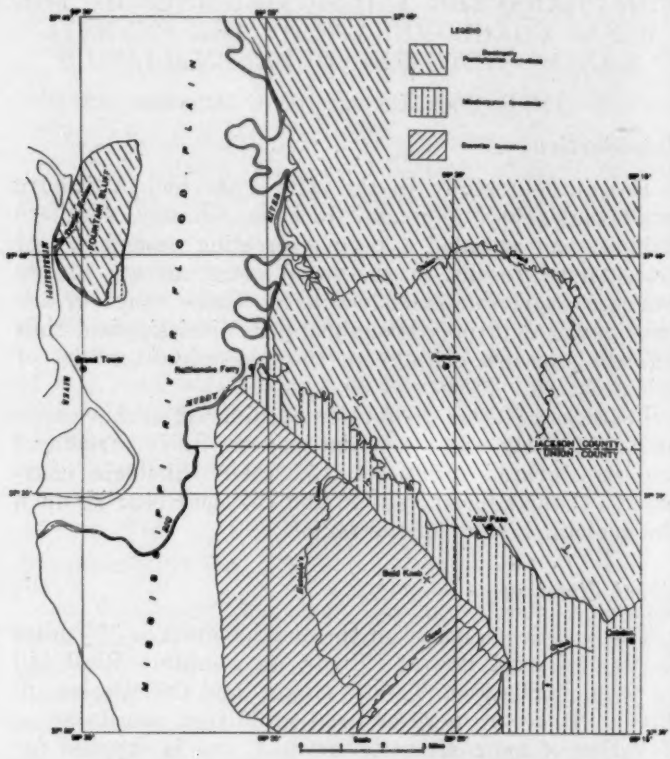


Fig. 1. Generalized bed rock map of Vicinity of Alto Pass.

Structural and stratigraphic relations.

The Pennsylvanian formations lie unconformably upon the Mississippian. Post-Chester and pre-Pottsville deformation and erosion occurred in the area, and as a result, the Pottsville conglomerate lies upon the beveled surface of the Menard, Palestine, Clore, Degonia, and Kincaid formations. Pre-Pennsylvanian streams cut valleys, some to a depth of 150 to 200 feet, and these contain the Pottsville beds.

The Chester series (Upper Mississippian) is exposed in this area in a relatively narrow belt trending southeast-northwest. See Fig. I. This belt has a maximum

width of four miles southwest of Cobden, and a minimum width of one mile a short distance west of Alto Pass.

Faulting, which is possibly entirely pre-Pennsylvanian, has affected all beds older than the Pottsville, and, as a result, the southeast end of the Chester belt has eastward dips ranging from 3° to 10° and an almost north-south strike. The northwest end of the belt has a maximum dip of 64° north-northeast and strikes N. 58° W. This indicates a plunging anticline, possibly an asymmetrical fold, which seems to have been formed simultaneously with the major faulting of the area. The regional dip is approximately 3° east-northeasterly with an average strike of N. 30° W.

The lower Mississippian strata are structurally parallel to the Chester series and abut against the Devonian strata on the south and west with a fault contact.

Aside from the erosional unconformity separating the Chester and Pottsville series there is a marked disconformity of dip, the average dip of the Pottsville being slightly less than 3° while the dip of the Chester varies from 3° to 64°. This angular contrast is not everywhere easily discernible, because the two series have approximately parallel strikes and the true relation is shown only in some valleys that are relatively free from debris.

The Pottsville basal conglomerate may be traced laterally into the Lick Creek sandstone, the oldest Pottsville formation in the area; consequently it is of the same age.

Lithologic character.

The usual criteria for recognizing the basal beds in the area are the coarse-grained texture and the presence of small well-rounded quartz pebbles. Locally, these features are poorly developed.

The conglomerate is a special phase of the basal beds, constituting a massive, firmly consolidated layer, composed of boulders, cobbles, and pebbles. Some of the boulders are two feet in their major dimension. The majority of the fragments are sharply angular to sub-angular. A few are ovate or discoid in shape. Most

of the larger boulders are silicified oolitic limestone. The medium sized fragments and most of the smaller ones are residual cherts. Some of the smaller cobbles and pebbles are silicified oolite, others are quartz, and a few are small quartz geodes. All of these are embedded in a matrix of coarse sand colored brown by a limonitic cement.

Paleontology.

The most interesting feature of the conglomerate from a historical point of view is the geologic range of the fossils contained in the residual chert fragments, and the well preserved characters of many fragile species. We are concerned only with the fossils included in the components of the conglomerate, and not the Pottsville fauna.

Most of the specimens listed herewith were collected from the residual chert fragments, some of which were weathered free from the sandstone matrix. These fossils are as follows:

NAME	KNOWN HORIZONS.
SIMPLE CORALS	
Zaphrentis spinulosa E. & H.	Throughout the Chester series.
Zaphrentis pellaensis (Worthen)	Ste. Genevieve limestone.
Zaphrentis sp.	Mississippian system.
COMPOUND CORALS	
Heliolites interstinctus(Linnaeus)	Upper Medinan and Niagaran.
Heliolites sp.	Ordovician through Devonian.
Favosites niagarensis Hall	Niagaran.
Favosites favosus (Goldfuss)	Brassfield-Geulph.
Favosites sp.	Ordovician through Devonian.
Lithostrotion canadense Castelnau	St. Louis Limestone.
Lithostrotion proliferum Hall	St. Louis Limestone.
Cyathophyllum sp.	Silurian through Devonian
Cladopora sp.	Silurian through Devonian
Cladopora sp.	Silurian through Devonian
CRINOIDEA	
Agassizocrinus sp.	Throughout the Chester.
BRYOZOA	
Archimedes sp.	Mississippian system.
Fenestella sp.	Devonian to Pennsylvanian.
Batostomella sp.	Silurian through Permian.

NAME	KNOWN HORIZONS.
BRACHIOPODA	
Spirifer bifurcatus Hall	Salem limestone.
Spirifer leidyi N. & P.	Chester series.
Spirifer louisianensis Rowley	Upper Kinderhook and lower Burlington.
Productus ovatus Hall	Kinderhook through Chester.
Productus cf tenuicostus Hall	St. Louis Limestone.
Productus sp.	Mississippian through Pennsylvanian.
Diaphragmus elegans (N. & P.)	Chester series.
Composita trinuclea (Hall)	Salem through Chester.
Composita lewisensis Weller	Throughout the Mississippian above the Burlington limestone.
Delthyris clarkvillensis (Winchell)	Louisiana limestone. (Lower Kinderhook).

The above list of fossils includes 16 which could be specifically identified, and 11 which could be generically but not specifically identified. Fragments of 7 different brachiopods, 10 different compound corals, and one crinoid were also found but could not be further classified. It is very interesting to note that the definitely known species range in age from lower Silurian through upper Mississippian.

Inferences suggested by the evidence.

The wide range in the age of these fossils is extremely suggestive of the geology of the land areas during the Pottsville epoch. Likewise, the texture and mode of occurrence of the conglomerate reveal the paleophysiography of the area:

Some of these suggestions are as follows:

(1) The materials composing these beds in Jackson and Union Counties, Illinois, were probably derived from sedimentary beds since no evidence of igneous or metamorphic materials has yet been found.[1]

(2) During late-middle or early-upper Pottsville time[2] the Pottsville seas of southern Illinois received sediments from land masses which were composed of Silurian, Devonian and Mississippian strata.

[1]The Pottsville of Pope County, Illinois, contains a few fragments of granite, some of which are as large as one's fist. Personal communication with Professor Stuart Weller, Chicago University.

[2]The Hardin County, Illinois, Pottsville has been determined by David White to be equivalent in age to the late-middle or early-upper Pottsville of eastern United States. See Ill. State Geol. Surv. Bull. No. 41, pp. 223 and 227, 1920.

(3) The highland masses were in Missouri and Illinois south and west of the present area while the area to the north and east was inundated.

(4) The highlands were of sufficient height to furnish relatively steep gradients to their northeastward flowing steams. These steams cut valleys comparable in size to those of Clear, Hutchins, and Cedar creeks.

(5) Most of the materials in the conglomerate apparently were transported a comparatively short distance, as is indicated by the preservation of minute characters on fragile shells, and by the paucity of well rounded fragments.

(6) The present beds of conglomerate mark approximately old stream mouths, marine embayments, or both. The thinning of the massive basal to the north supports this view, as does also a theoretical consideration of shore and tidal currents in small embayments.

(7) These small bays and the entire Pottsville sea were relatively shallow as indicated by the predominance of very coarse materials in some places, and the abundance of cross-bedding and ripple-marks in other places.

(8) The conglomerate is the shore phase of the Lick Creek sandstone and was deposited under marine conditions. This is shown by the fact that it can be traced laterally into the Lick Creek formation which contains marine fossils.

Since no mineralogical examination of the matrix has been made, little definite information regarding its origin and source can be given at present. It does seem likely, however, that the Pottsville conglomerate in this area came from the south and west, and, for the most part, represents reworked sediments.

Acknowledgments.

The data and materials used in the preparation of this paper were collected by the writer during the field seasons of 1923 and 1924. They have since been worked up as a part of his thesis for the Master's Degree at the

University of Illinois. Acknowledgments are due Messrs. Frank Krey and George Ekblaw, of the State Geological Survey, with whom the writer was associated in the field, and Professor T. E. Savage, who checked the fossil identifications and gave many valuable suggestions.

TRANSITION BEDS BETWEEN THE ST. PETER SANDSTONE AND THE PLATTEVILLE LIMESTONE[1]

ARTHUR BEVAN, UNIVERSITY OF ILLINOIS

On account of their wide distribution in the upper Mississippi Valley and their distinctive characteristics, the middle Ordovician St. Peter sandstone and the Platteville limestone have been described frequently by geologists working in this region from the time of the first scientific explorations to the present. The formations are in marked contrast to each other, as the older St. Peter sandstone is a conspicuous friable, light-gray to white sandstone whereas the Platteville is a fossiliferous limestone.

As the result of detailed mapping of counties in northeastern Iowa in this belt of Ordovician formations, Calvin recognized and described an intervening formation which he named the Glenwood shale. This formation is a very persistent, somewhat sandy, bluish-green shale. It is seldom more than a few feet thick. Similar beds have since been reported at the base of the Platteville at several localities in Minnesota, Wisconsin, and Illinois. The southernmost reported occurrence is in Calhoun County, Illinois. The formation crops out at several places in La Salle, Lee, and Ogle counties. In most places it is the typical more or less sandy shale, but in the vicinity of Oregon, Illinois, it is a fine to medium-grained sandstone with little or no shale.

In some sections the Glenwood appears to be closely associated with the underlying St. Peter sandstone, but in a few places a slight though well-defined erosional unconformity exists at its base. Although the lithologic change to the overlying Platteville limestone is generally abrupt, the formations are everywhere apparently conformable. In one place Platteville fossils have been reported from beds that probably represent the Glenwood horizon.

[1]Published by permission of the Chief of the Illinois State Geological Survey. This is an abstract of a short paper based on work done in mapping the Oregon quadrangle for the Survey. The paper will be published in the "Reports on Investigations" series of the Survey.

The typical Glenwood is absent in some places, and it is replaced laterally by a series of transition beds of variable thickness. Such beds have seldom been described from outcrops, but they have been reported in a few well sections in northeastern Illinois. In the detailed study of the geology of the Oregon quadrangle two sections of thick transition beds of rather unusual character were observed in ravines a few miles east of Oregon. The series consist of alternating thin and thick beds of sandstone, shale, and limestone, which differ in sequence and thickness in the two sections. Some of the shale and sandstone is similar to the Glenwood in color and texture, but a few layers of sandstone are recurrences of typical St. Peter sandstone. The limestone resembles more or less the overlying Platteville limestone. The maximum thickness is about 40 feet.

Inasmuch as the geologic and geographic conditions of northern Illinois at this stage in its history are recorded in the Glenwood and associated strata, an attempt is made to interpret the conditions under which these formations were deposited.

POST-CHESTER, PRE-PENNSYLVANIAN FAULTING IN THE ALTO PASS AREA

GEORGE E. EKBLAW, ILLINOIS STATE GEOLOGICAL SURVEY

A suspicion that post-Chester, pre-Pennsylvanian faulting occurs in Illinois has existed since St. Clair's reconnaissance of oil structures in southern Illinois.[1] This suspected relation was established as a fact in the summer of 1924, when the geology of the Alto Pass quadrangle was mapped for the Illinois State Geological Survey. Mr. Frank Krey, formerly of the Survey, inaugurated and collaborated in the work which established the relation as a fact. Mr. Russell S. Poor assisted both Mr. Krey and the author in the field.

The area under discussion comprises seventeen square miles, lying in a belt that extends from Pomona nearly to Mountain Glen and passes just west of Alto Pass. Erosion is in a mature stage, and the loess that mantles the area is so thick that great difficulty is encountered in finding outcrops satisfactory for correlation. Nevertheless, assiduous search revealed data sufficient to warrant the presentation of the following statements concerning the faults in the area as facts.

Fault No. 1. This is the major fault of the region. It is composed of several segments that vary slightly in direction, but the resultant general trend is northwest-southeast. It doubtless continues across the Mississippi Bottoms to the faulted area of Grand Tower, and thence across the Mississippi River into Missouri. It dies out two miles northwest of Mountain Glen. The maximum throw of the fault, measured southwest of Alto Pass, is approximately 2,000 feet if the zone of drag is ignored. This is sufficient to bring the Clear Creek chert of Devonian age level with and above Lower Pennsylvanian sandstone. However, along the immediate fault zone Lower Mississippian strata are in juxtaposition with the Clear Creek chert. The actual fault is rarely seen. The evidence allows the age of the fault to be determined no closer than post-Mississippian.

[1] St. Clair, Stuart., Oil Investigations in Illinois in 1916—Parts of Williamson, Union, and Jackson counties: Ill. State Geol. Survey Bulletin 35, 1917, p. 53.

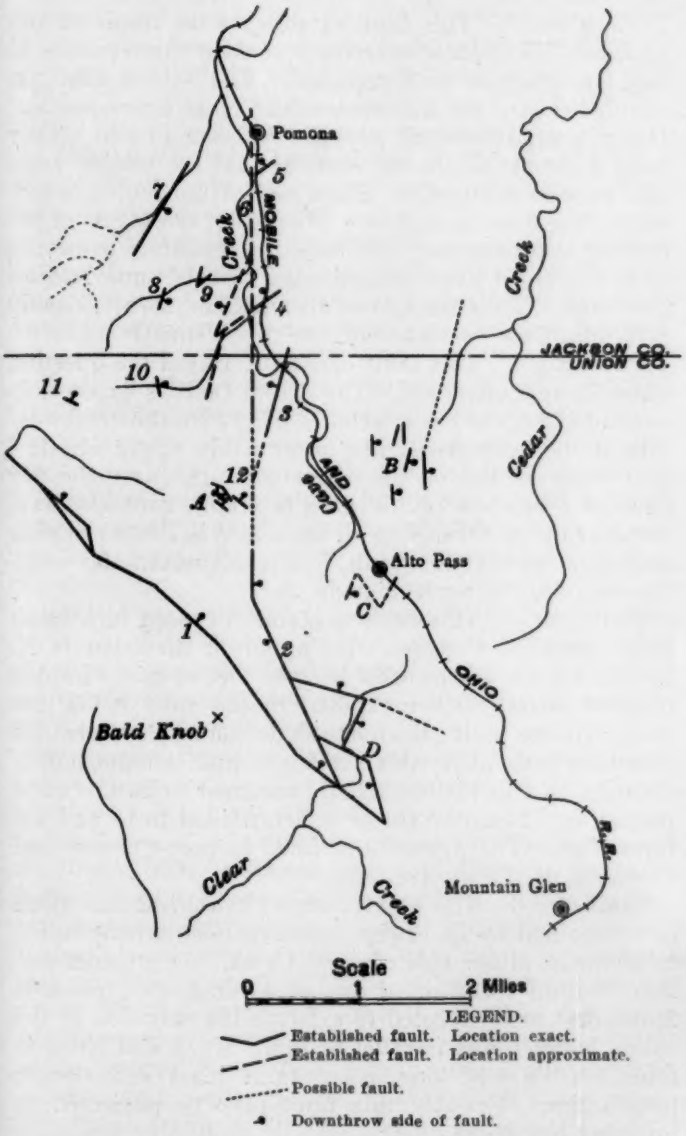


Fig. 1. Map showing some of the faults in the immediate vicinity of Alto Pass, Illinois.

Fault No. 3. This fault establishes the thesis of this article. The fault was actually seen in three places, so that its direction is determined. The strata that are visibly affected are Palestine shale, Clore limestone, and Degonia sandstone, all younger Chester in age. They have a strong dip to the east, so that the section from east to west exposed on either side of the fault is sandstone, limestone, and shale. Therefore, the throw of the fault is approximately 100 feet. Immediately overlying these deformed strata is horizontal, basal Pennsylvanian sandstone. Thus the age of the fault is unquestionably determined as post-Chester and pre-Pennsylvanian.

Fault No. 4. This fault originally raised the question which is now answered. The actual fault is exposed in a railroad cut and has a trend N. 55° E. On the northwest side of the fault the strata, presumably upper Chester, lie horizontal, but on the other side massive Chester limestone dips sharply towards the fault, doubtless as a result of drag. Overlying all the strata is Pennsylvanian sandstone, so that this fault, too, is unquestionably post-Chester, pre-Pennsylvanian in age.

Fault No. 5. This fault is plainly exposed in a small gully south of Pomona. Its apparent direction is N. 55° E. On the northwest side forty feet of thinly bedded Chester sandstone are exposed in the gully below the fault. At the fault calcareous shale containing irregular limestone beds abuts this sandstone and is immediately overlain by a sandstone that is assumed to be the same formation. Thus the throw is determined to be at least forty feet. The age of the fault is post-Chester and probably pre-Pennsylvanian.

Fault No. 6. The approximate position of this fault is determined by otherwise unreconcilable stratigraphic relations on either side of Cave Creek. As no continuation of fault No. 5 or of any of several other possible faults that are suspected to exist on the east side of the valley between and parallel to faults No. 4 and No. 5 is found on the west side, some fault must cause their termination. Possibly this fault may be projected to intersect No. 2.

Fault No. 9. Two small faults, probably intersecting, are included. The west one trends N. 20° E., and the

east one N. 50° E. Along the west one the strata dip eastward; along the east one they dip westward. Only Chester strata appear to be affected, but the complete relations have not as yet been ascertained.

Fault No. 10. This small fault, trend N. 5°-10° W., visibly affects only the Degonia sandstone.

Fault No. 11. This fault trends N. 65° W., and has a throw of probably only thirty feet. It visibly affects only middle Chester strata.

Fault No. 12. The relations of this fault are very obscure. The strata affected are probably middle Chester. They have a strong dip along a strike N. 50° W., while Pennsylvanian strata immediately to the east are horizontal.

Fault No. 2. This northnorthwest-southsoutheast trending fault has not been actually seen. However, in its northern portion, the stratigraphic and normal structural conditions leave no doubt that a fault exists, and a projected southern continuation is supported by stratigraphic relations. Its throw is probably not over one hundred feet. Its age can be determined as post-Mississippian.

Fault Area D. Unusual relations of the Mississippian strata in this area can be explained only by the introduction of several faults, none of which have been actually seen, and whose ages can therefore be assigned only as post-Mississippian.

In addition to these examples, there are other minor faults which are post-Pennsylvanian age. A few of such examples are explained below.

Fault No. 7. The position of this fault is determined by three facts. First, a forty-foot Degonia sandstone bluff that can be traced continuously around the ravines at the head of the valley terminates abruptly at the point mapped as the southern extremity of the fault. Second, this same sandstone bluff can be traced continuously also along the western side of the lower part of the valley, but its counterpart is lacking on the eastern side. Third, along the east bank of the creek, steeply dipping sandstone is frequently exposed. This fault has an approximate trend N. 30° E., and an estimated throw of

more than one hundred feet. Since Pennsylvanian sandstone is apparently included in this movement, the age of the fault is presumably Post-Pennsylvanian.

Fault No. 8. This is a small fault, trend N. 15° E., that visibly affects only Pennsylvanian sandstones.

Fault Area A. This area includes three small faults, all visibly affecting only Pennsylvanian strata. The north fault of the group trends N. 70° W., the east one N. 25° W., and the south one N. 45° W. They appear to mark the limits on three sides of a graben block.

Fault Area B. This area includes several small faults whose relations are not as yet established. There is some evidence that they are the consequences solely of slumping of large masses of Chester formations.

Fault Area C. This area is similar to area B, but the fault-like conditions are more prominent.

Many other minor faults might be cited, but the examples that have been explained are sufficient to show (1) that the Alto Pass area is an intricate maze of normal faults, (2) that these faults occurred during at least two periods of deformation, and (3) that while the age of one of these two periods is post-Pennsylvanian, the other is post-Chester and pre-Pennsylvanian.

A PROLIFIC COAL FIELD

FRED R. JELLIFF, GALESBURG

One hundred and twenty-six borings for coal vein No. 1 in an area comprising eighteen sections of Knox township, Knox County, Ill., afforded me exceptional opportunities for the study of the logs. These were made by the Cripple Creek Coal company to map with accuracy the boundaries of vein No. 1. It was the purpose sooner or later to sink a shaft at the most advantageous point and mine this vein where it is of sufficient thickness. In thirty-three of these borings six veins are found; in forty-nine, five; in thirty, four; in seven, three; and in one, eight.

The vein No. 1, as delineated, seems to occupy a channel within which it maintains usable thickness, but outside of which the vein thins and often disappears. Indeed, there seem to be a series of these channels as if there had existed a swamp through which they coursed with occasional connections. The general direction of the main channel is to the southeast, and it varies from one-eighth to three-quarters of a mile in width, with a length of about seven miles to the point where the borings terminate. The thickness of the vein varies from four feet to six and one-third feet, and the drill samples show that the coal is of excellent quality.

In fifty-five of the borings the vein was found of adequate thickness, while in the other seventy-one it was not thick enough to mine or the borings had gone below its horizon and it did not exist, although characteristic rocks of the vein might have been disclosed.

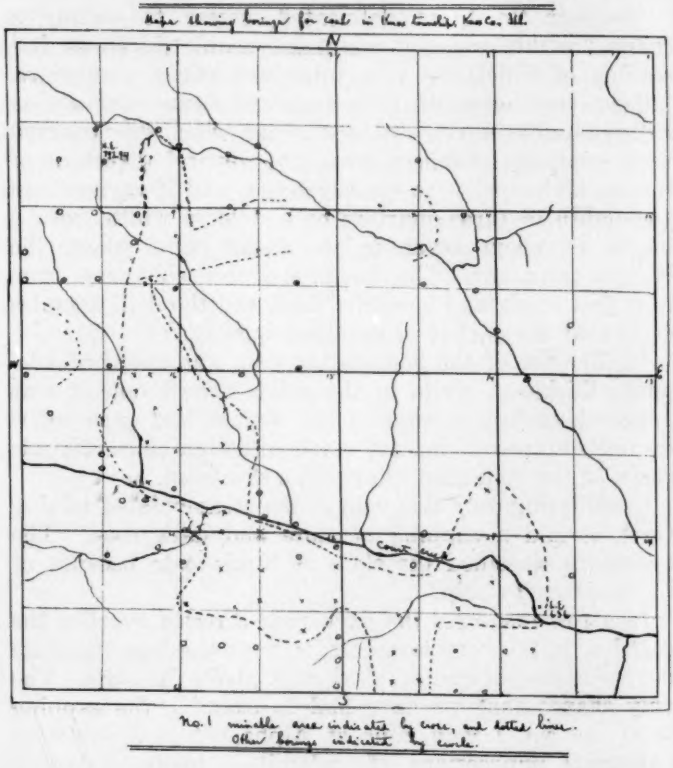
Considering only this vein in the contemplated mining tract, it had a capping of slate and dark rock. The operators classified the slate as block slate because of its tendency to chip.

In a few instances the dark rock directly overlies the coal but in the very large majority of the logs the slate is above the coal and the dark rock above the slate. The only chance that we have had to examine the capping is at the No. 1 vein mine at Alpha, where it contains numerous impressions of calamites, many irregular

lumps and sheets of pyrite and lingula and spirifer types of brachiopods. In the dark rock and semi-slate capping of the same vein in a mine south of St. Augustine the same profusion of calamite impressions was noted.

The slate varies from three to ten feet in thickness and the dark rock from one to eight. These two formations are quite characteristic of the vein, but are not always found. Eight of the borings show a gray shale above the vein, if the terms used by the drillers are correct.

Under this vein almost invariably is found a fire clay, although occasionally this is found under a brownish



clay, called brown bottom, which, however, seems to grade into the fire clay. The gray shale beneath the fire clay, I am informed, is an invariable sign that the horizon has been passed.

The elevations of this vein seem to determine to a considerable degree the elevations of the veins above it. It is by no means level. What seem inexplicable changes may occur within short distances. For three miles to the southeast there is an ascent from 487 to 604 feet, and the latter seems the highest elevation at which the vein is found in the drilled area, and is the peak of an anticlinal ridge that is reached from the north with the vein ranging from 521 to 580 feet in elevation, until the peak at 604 is attained.

One can see in the ranges of elevations the trough in which the coal was formed. On one side there will be elevations of 542, 553, 577, 571, etc.; in the center, elevations of 532, 543, 561, 569, etc.; and on the other side, elevations of 551, 566, 577, etc.; and the same tendency is shown in the eastern extension of the vein. One might speak of the general topography of the vein as undulating.

ILLUSTRATION

The whole series of nine veins is embraced in the following section:

	Soil and clay	20 ft.	
S	Coal	3 ft.	23
	Gray shale	29 ft.	
H	Coal	3 ft.	52
	Light shale	22 ft.	
	Sandstone	37 ft.	
HN	Coal	1 ft.	114
	Gray shale	24 ft.	
	Dark shale	20 ft.	
A	Coal	2 ft.	159
	Light shale	15 ft.	
B	Coal	1 ft.	176
	Gray shale	5 ft.	
C	Coal	1 ft.	182
	Light shale	18 ft.	
	Dark shale	8 ft.	
	Dark rock	2 ft.	

D	Coal	1 ft.			211
	Light sand shale	9 ft.			
	Dark slate	6 ft.			
E	Coal	2 ft.			227
	Light shale		8	in.	
	Dark rock	1 ft.			
	Block slate	5 ft.	6	in.	
X	Coal	4 ft.	6	in.	236.2
	Brown bottom		4	in.	
	Fire clay	1 ft.	8	in.	
	Total	242 ft.	8	in.	

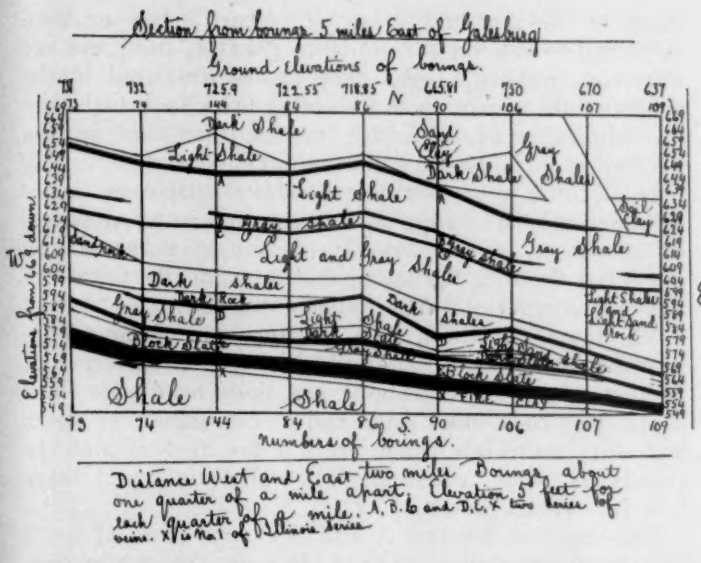
In this series S stands for the summit vein; H for High vein; NH for next to High vein; A, B, C for the first series of three veins, and D, E, X for the second series, X standing for vein No. 1.

A group of 126 borings in a single field enables one to perceive some of the vagaries of vein formation; to behold the appearance of veins, their thinning out and disappearance, and then their reappearance on the other side of the break and by no means always at the same level. I believe that wherever possible the whole series of logs should be procured and mapped.

In the present case, one has the privilege of seeing the changing of shales into sandstones, the uniformity of some of the formations over much of the field, the underground topography of each vein and the contiguous formations and their interrelations.

From the parallelism of the veins, even in the changes of level and topography, one is almost forced to conclude that they were deposited in a nearly level position, one above the other, the variation being in the general dip to the southeast, and that the present undulating appearance is due to the simultaneous settling and pressure, which, due perhaps to the difference in the composition of the formations, has forced the veins and their intermediate strata out of alignment.

To correllate these veins with the series for Knox county, given in the Reports of the Illinois Geological Survey, is a difficult matter. The Reports bear the date of 1870 and were issued when borings were not numerous, and when reliance had to be placed in many instances on exposures in the hillsides and along the streams. Even in later reports seldom does one see the mapping of a field over a considerable area, but dependence is had on a single boring and its revelations, whereas another boring, even a short distance away, might disclose another relationship.



Because of the difficulty of correlation, we have seen best to adopt lettering, as in the foregoing section.

In only one boring does the vein highest in the series appear. This is well toward the north part of the field, and the seam is struck immediately under the soil and surface clay at a reported depth of twenty feet.

The distance to the next vein below in this one boring is 29 feet, and this interval is occupied by a gray shale. In the higher levels this vein is fairly constant, and its elevation ranges from 709 to 745 feet. In two borings another vein appears; in one case it is 60 and in the other but twelve feet below the vein just mentioned. Regarding the latter as the main upper vein and taking it for the starting point, one finds ranging from 120 to 109 feet below it a remarkable series of three veins.

These exist within a space of thirty feet and usually less. I have named the series A, B, and C. In all the borings save the two mentioned, the entire distance between A and the main upper vein, which is indicated by the letter H, is occupied by clay shale with occasional beds of sandstone, constituting in the areas where there is no sandstone beds of large economic value. The

range of this material in the hills where it has not been subjected to erosion is from 60 to 104 feet, and there are numerous out-croppings. The shales are used in the manufacture of paving and building brick for which they are admirably adapted, due to the fact that in the process of burning the material vitrifies.

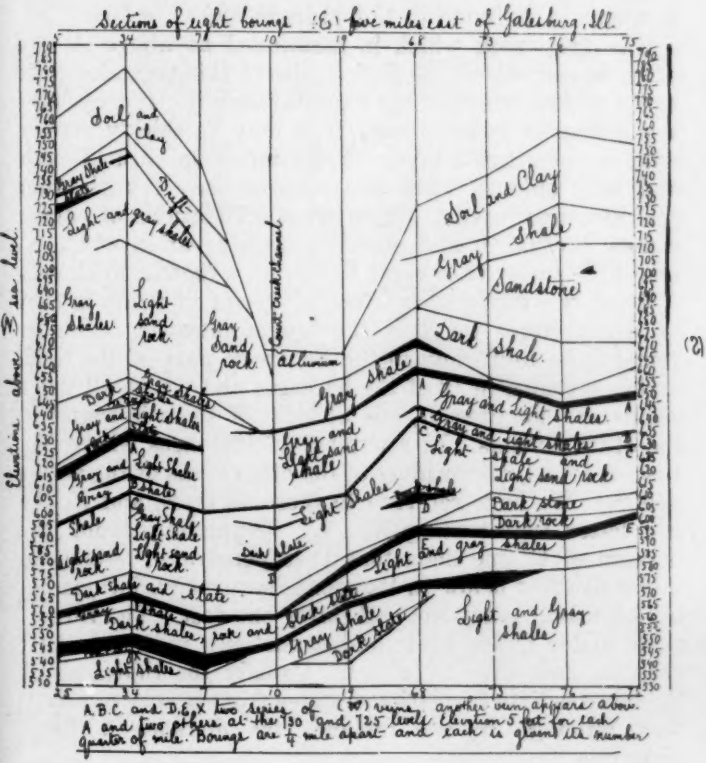
In addition to the occasional beds of sandstone, layers of which may interrupt the face, there are many lenses of sandstone and ironstone concretions that may be scattered through the mass, and occasionally there are lines of concretions that indicate the dip.

The lowest elevation of A, the top vein of the group, is 595 feet and the highest 678, showing a variation of 83 feet. Immediately above one finds as a rule dark shale, gray rock, block slate, and occasionally gray shale. The dark materials range from a few feet of slate to twenty-six, while where the gray shale is found there is a dark rock above it.

The distance between A and B ranges from 14 to 22 feet, but in the main is 15 to 18. In nearly every instance, the material between A and B is light or gray shale. Only in a very few instances is there a thin vein of slate over B.

Between B and C there is a thin vein of "shale", as the driller termed it, but it is more likely fire clay. In all the borings this occurs without any interruption, and with startling suddenness there appears the vein C below. The thickness of this shale formation is from three to six feet and it seems a perfect guide. The dark formations above A sometimes contain bands of concretions of an iron ore of a lenticular or cylindrical shape, and in these are found coal measure brachiopods and occasionally a trilobite. These lines of concretions may be but a short distance apart and a dark shale or even a light one may separate them. One of the characteristic rocks eight to six inches thick, having the appearance of a mud formation, contains numerous shells of nautilus and gasteropod groups and of scallops and many species of brachiopods and bryozoans. The massive and often hard sandstone immediately above, which shades off into shale, contains the remains of plants, including many familiar coal measure forms.

These are seen to good advantage in the ravines made the last year by heavy rains down an anticline, the axis of which extends in a southeast and northwest direction. Here one can find in profusion great stems of calamites, sigillaria, lepidodendron, cordaites, and imprints of numerous species of ferns. Where the slate occurs immediately above A, it contains the remains of sharks and ganoids, of waterfleas, and shells of the nautilus and brachiopod groups. The life of this series of formations above A is varied and exceedingly interesting.


Sections of right bourge (E) five miles east of Galesburg, Ill.
Elevations above M. sea level.
Soil and Clay
Drift
Light and gray shale
Gray shale
Light sand rock
Gray sand rock
Dark shale
Gray shale
Gray and Light shales
Light and dark shale
Light sand rock
Dark stone
Dark rock
Light and gray shales
Sandstone
Alluvium
Coal
Dark slate
Light shales
Light and gray shales
Dark shale and slate
Gray shale
Dark slate
Light shale
Light sand rock
Gray and Light sand shale
Dark shale
Light and gray shales
A B C and D E X two series of (W) veins another vein appears above.
A and two others at the 730 and 725 levels Elevation 5 feet for each quarter of mile. Bourge are ¼ mile apart and each is given its number

The group A, B. C serves as a means of locating No. 1, which may be found 60 to 104 feet below A and more generally 70 to 80 feet. If the rocks characteristic of No. 1 are not found within this limit, it is not likely that the vein will be located at all.

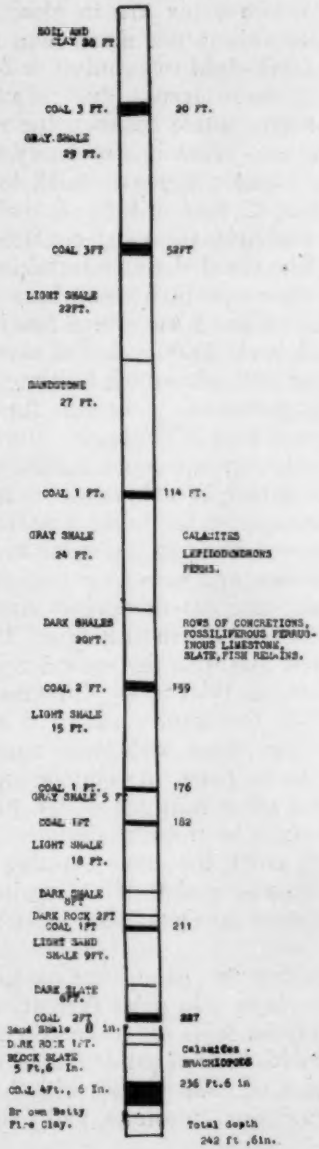
The three veins A, B, C underlie much of the field and are thin, but constant, never exceeding two and a half feet in thickness, and where the shale is exposed above A there might be a joint use of the clay and coal in brick making as was done at the old Pioneer plant.

The entire series is found in seventy-six of the borings. A is found in 118, B in 85 and C in 108.

The gray rock which is mentioned as above A can often be seen above the dark shales of this vein along the banks of streams that have cut through it. It may have a covering of cone-in-cone, or it may be thickly strewn with a commingled layer of gasteropods, brachiopods and bellerophons, while the interior may reveal other coal measure fossils. Quite often infiltrations of calcite ramify through it and cause its disintegration when exposed. Usually it is eight inches to a foot in thickness.

What one might term a second series of veins is that of which No. 1 or X is the lowest member. This is found quite uniformly in the Southern part of the field, and is revealed in 18 of the borings; and where all three seams are not present, one at least of them is found in the other borings. In a number of instances where No. 1 is not found, one or more of the other veins of the series will be. We have referred to these as D, E, and X, the last letter representing No. 1. Estimating from the horizon of C, one finds that D is penetrated twenty to thirty-five feet below it, the more frequent variations being between twenty-one and thirty-one feet. The formations under C are shale and sandstones until the dark rock or slate over D is met. Usually the thickness of the intermediate formations ranges from twenty to thirty feet, although in one instance the distance is fifty-eight feet.

GENERAL SECTION COAL BORING 5MILES EAST OF GALESBURG, ILL.



The interval between E and X is not great and occasionally the two veins are in close proximity. In several instances this is not more than nine feet. The usual range is from eight to twenty-two feet, and in only two instances is there excess, due to an extraordinary development of gray shale between the veins.

D and E are also often in proximity, and in borings where No. 1 is found sufficiently thick to mine they are never more than 22 feet apart. E over much of the entire field is probably the most consistent vein of the entire series. The usual shale material is found between D and E, with slate and dark rock above the coal.

The approach to No. 1, save in a few instances, is indictated by dark rock, gray rock and slate, while underneath the vein is either a brown bottom, or fire clay, or simply fire clay. The cap may run three or four feet or be twenty-seven feet in thickness. In case one of the three veins of this group is missing, there is often a layer of slate or dark rock to indicate its relative position and this is true even of the horizon of No. 1.

Another series of borings six miles to the southwest, fourteen in number and covering two square miles of Orange township, disclose the same veins, seven to five in number, with No. 1 ranging from 190 to 213 feet below the surface, and with the second vein from the top four to five feet in thickness. Information from the southeast part of the county shows a series of veins that seem to be correlated with those named.

There seems to be much in common in this group of D, E, and X and the conditions under which they were produced must have been quite similar. We have here three veins with much the same capping and the same intermediate series of rocks. Even under the fire clay of X the drill passes into gray shales, so peculiar to the series.

The materials that we have been considering are the soil, the surface clays, and drift formations, ranging in the higher elevations from 20 to 68 feet in depth, light and gray shales with beds of sandstone of varying colors, gray rocks, series of dark shales with bands and concretions of ferruginous limestone, and fossiliferous mud

rocks, slate in several forms, nine veins of coal, and the fire clay directly under the coal. We have found that six of the veins form groups of three veins each, that are not far apart, and that No. 1 is the base of the bottom group. We have noted the heavy bed of shale above the A, B, and C group, adapted to the manufacture of brick.

We have wondered should a shaft be sunk, whether it would not be possible to attempt a simultaneous development or at least test of the shales and fireclays of the various seams. It is possible that these may be of economic value and could be mined in connection with the thinner veins which would thus become available for consumption. This seems to be a problem worthy of consideration, wherever a similar system of veins is so advantageously approached as in this field.

Along the No. 1 channel, the average thickness of the six veins A, B, C, D, E, and X is about eleven feet, and as under modern methods only X is mined six to seven feet are not utilized. Where the higher veins appear, the total thickness of the coal is of course increased, and the amount that is not utilized is correspondingly increased. The greatest thickness of coal appears in a boring that goes through eight veins and this is 15 feet, seven inches.

SOME FEATURES OF CONTINENTAL GLACIATION

TERENCE T. QUIRKE, UNIVERSITY OF ILLINOIS

Continental glaciation preserves in its deposits the record of its activity, and it buries beneath its own load the deposits made by earlier glaciers. Thus in Illinois and Iowa particularly it is possible to work out the history of repeated glaciations on the basis of deposits of different characters and ages separated from one another by the ancient soils, weathered zones, and sheets of gumbotil which are indisputable evidence that long times elapsed between the successive glaciations. In certain critical sections which have been exposed by running water or by human enterprise these indications of glacial history afford the opportunity for reliable interpretation. However, in the areas of glacial erosion the story is not so clear, for the glaciers which leave their telltale deposits in some places remove the evidences of their antecedents in areas of erosion. This paper has to deal with those regions which are almost barren of glacial till although severely glaciated.

The regions of glacial abrasion are largely to the north of the Great Lakes, and the areas of deposition are largely to the south. Roughly speaking the glaciers spread out from an area north of the lakes, pushing southward into an ever widening arc, until they were wasted by the warmer and drier climate of the south. The glacial deposits might be expected to be most abundant near the place of greatest wastage, which corresponds generally with the places of greatest advance of the ancient glaciers; on the other hand, it is evident that the area north of the Great Lakes has been scoured naked by glaciation to such an extent that glacial till is uncommon. The area of deposition is approximately twice as large as the area of erosion, and supposing the Pleistocene glacial deposits of all ages to be on an average forty feet thick, the amount eroded to provide these deposits appears to have been on an average about eighty feet deep. Unlike glacial deposition, glacial erosion is highly selective as to the bed rock, cutting much more deeply in some places than in others;

thus, with an apparent average depth of erosion about eighty feet, the maximum depth of erosion may well have been more than one-hundred feet.

It is proper to recall that there have been four episodes of Pleistocene glaciation aside from the Early and Late Wisconsin invasions, which were separated by very long intervals of time, and that a great deal of the deposits must have been removed by erosion before the following deposits were laid down. How great were the thicknesses of till which have been removed no person seems to have estimated, but it seems quite conservative to consider that it may have been as great as that which remains, for that which remains is after all merely fragmentary relics of the once extensive layers of pre-Wisconsin deposits. On the other hand, much of the material still preserved in the present terminal and ground moraines is of local origin like that previously eroded. Consequently it is apparent that no definite figure can be given as the amount which has been stripped from the crystalline masses north of the Great Lakes. At a maximum it may have been as much as one hundred feet on an average, and as a minimum it may have been as much as ten feet. Unluckily erosion removes the evidences of its work and definite proof is lacking. However, there are numerous lines of evidence which indicate that the depth of erosion was very considerable, and that maximum glacial erosion affected different places during different invasions. The places of great erosion were those peculiarly vulnerable to glacial erosion. Glacial erosion above all is highly selective in its attacks. Its selection depends, aside from the thickness, speed, coldness, and adequate load, upon the character of the bed rock, upon its jointing, and upon its stratigraphic attitude.

Fig. 1. Selective glacial erosion leaves diabase dykes protruding from quartzite hills like walls.

A massive igneous rock is more easily eroded than a hard rock-like quartzite, provided the quartzite is not jointed; in the case of a jointed rock, however, the quartzite is quarried by plucking and by being slipped out of its position along its planes of jointing, whereas the massive crystalline rock resists all glacial erosion except scour, which is nearly always relatively insignificant as compared with plucking and quarrying in blocks. On the north side of the Great Lakes there are numerous hills composed of well bedded quartzite with a ridge at the top composed of diabase which rises above the top of the quartzite hill like a wall. (Figure I.) Diabase is much more easily weathered than quartzite, it is not nearly so hard as quartz, and quartz veins stand out upon the glacially scarred surface of diabase, but when subjected to the erosion of continental glaciers the diabase rock is much stronger to resist quarrying than the hard, but well jointed quartzite. In several cases these diabase dykes have been found standing above the surrounding glaciated quartzite, like walls twenty feet high. Previous to glaciation these dykes were probably the location of valleys due to the easy erosion of the diabase; consequently their present attitude in relation to the quartzite indicates that not only was the quartzite eroded until it was level with the diabase but that it was carried away by glaciation so much faster than the diabase that the diabase relatively emerged from the quartzite. The difference in level of the top of the diabase and the surface of the quartzite indicates the difference in the amount of glacial erosion which the two have suffered, which must be small in comparison with the total erosion of both. Twenty feet in the difference of the erosion suffered by quartzite and diabase at the top of a hill seems to indicate that the total erosion was considerably more.

Fig. 2. Glacial erosion is notable where the formations dip in the direction of glacial advance.

But the erosion of the bed rock in the areas of crystalline rock is rather insignificant when compared with the enormous quantities which were stripped away from the sedimentary formations in the general region of the great lakes. The most important factor in their case, aside from the natural weakness of the rock as compared with that of the crystalline rocks, was the fact that the formations were dipping away from the direction of glacial advance. (Figure 2.) The ice shoved against and over the upturned edges of the rocks and broke pieces off, bearing them away in front and on top of the ice, rolling part of the load beneath it as it advanced over depressions or outliers of crystalline rock. The tremendous increase in the thickness of the glacial deposits south of the edge of the sedimentary rocks indicates very clearly the enormous load which they contributed. Illustrations of the effects of stratigraphic positions of the metamorphic rocks within the crystalline areas are numerous enough. The illustration (Plate I ————) shows part of the Serpent quartzite dipping southward, rendered still more susceptible to glacial erosion by the development of splendid bedding joints. However, it is the position of the formation, dipping about thirty degrees downward, which renders the joints valuable aids to the glacial erosion. This picture shows a stoss surface. It illustrates the sort of thing which may be seen in many places where the rocks dip southward: rocks which are in themselves relatively weak, like the Paleozoic sediments, are naturally more susceptible to this type of erosion than the strong Huronian quartzites.

When the rocks do not dip in a direction favorable to glacial erosion the plucking is notably important on the south side of the hills. This is just as true of the large hills as of the small ones. The illustration (Plate II ————) shows the southeastern end of LaCloche mountains. One can see easily enough that nearly all the hills are glacially quarried into precipitous slopes to the south, and that they have been abraded into more gradual slopes on the north side. The dip of the rocks in La Cloche mountains is nearly vertical.

Cliffs of other types abound. One of the most remarkable features of the country north of the Great

Lakes is the great number of cliffs to be seen. Inasmuch as the general relief is about three hundred feet over large areas, most of the cliffs are small. Many of them border lakes and rivers, many of them do not, some of them rise from the edges of swamps, the swamps being due to the physiographic control of the cliff rather than the cliff being a product of the lake which gives rise to the swamp. Most, if not all of these cliffs quite obviously antedate the last glaciation, and nearly all of them are the result of pre-Wisconsin glaciations and interglacial periods of erosion. Some of these cliffs border large rivers adequate with time to form great cliffs, but many of them are far from both lakes and streams, obviously owing their form to extinct conditions of erosion. Among other rivers the Nipigon river seems to follow pre-Wisconsin cliffs, for its valley is not uniform in character. Near the great cliff on the eastern side of the river shown in Plate III, the western banks are relatively low, and a portage which has been traveled by the Indians for centuries follows the top of an esker in a valley. The relations of these features show that the lowland preceded the last glacier. Obviously the great cliff is not the side of a V-shaped valley; consequently it must have been produced by the erosion of earlier times. Ordinarily cliffs which are not valley walls are made only by faulting, by the erosion of standing waters, and by glacial sapping. The abundance of cliffs north of the Great Lakes seems to indicate that glacial sapping and lake work have been prevalent in many places where today there are inadequate lakes and no glaciers. The cliffs themselves indicate the activity of pre-Wisconsin glaciation.

The antecedent character of these cliffs and their associated features probably indicate in themselves that there have been several times of glaciation in Pleistocene times, but it is very difficult to read their signs aright. One reason for this difficulty is of course because the country is covered with trees, which obscure observation. but the main reason is that all processes of erosion destroy the antecedent details of physiography, and were it not that glacial erosion is selective

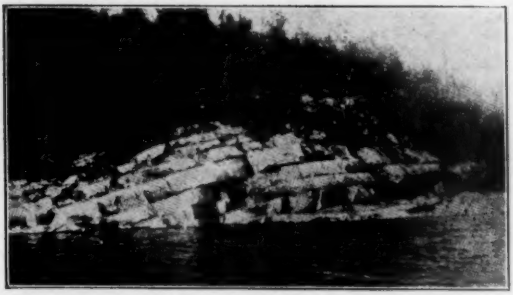


Plate I. The stoss side of a formation dipping in the direction of glacial advance. Rocks in this attitude are very vulnerable to glacial erosion. The Serpent quartzite (Huronian Series) on Lang Lake, Ontario.

Plate II. LaCloche Mountains two miles northwest of Killarney, Ontario. Note the scarps on the southern faces of the hills produced by continental glacial plucking. Geological Survey of Canada.

Plate III. A Pre-Wisconsin Cliff on the east side of the Nipigon River, Ontario. Most of the numerous cliffs of this type in Ontario appear to be of glacial or interglacial origin.

in its misses as well as in its hits there would probably be no indications left. However, in Bridgeland township,[1] east of Sault Ste. Marie, there is a hanging valley discharging into a swamp land above which it has built up a great alluvial cone. This valley runs east and west and is scoured on the north side and plucked into cliffs on the south side by the last glaciation. Consequently the valley is pre-Wisconsin. However, this is a hanging valley, and was a hanging valley at the time of its glaciation; consequently the cliff at which it ends is a pre-Wisconsin glacial valley. There are no geological processes in that region known to make hanging valleys except glaciation, and inasmuch as the hanging valley is over a hundred feet above the swamp at the foot of the cliff in such a place that the valley cannot be traced beyond the cliff, it appears that the hanging valley represents a stream which cut through glacial drift onto a buried diabase cliff. Apparently it was a superposed stream. The glaciation which made the

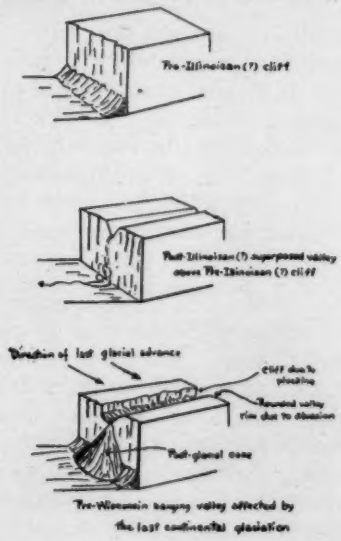

Pre-Illinoisan (?) cliff
Post-Illinoisan (?) superposed valley
above Pre-Illinoisan (?) cliff
Direction of last glacial advance
cliff due to plucking
Truncated valley rim due to abrasion
Post-glacial cone
Pre-Wisconsin hanging valley affected by
the last continental glaciation

Fig. 3.

[1]Geol. Surv. Canada. Mem. No. 102, pp. 14-15.

drift through which the stream cut is not likely to have been the glacier which made the cliff, or if the cliff had been made by lake work, the lake may have owed its existence to earlier glaciation; consequently it appears that there are here three times of glaciation indicated. First, a glaciation which caused the cliff, second, a glaciation which buried the cliff with deposits through which a stream cut until it became superposed upon the top of the diabase hill, then erosion removed part or all of this glacial deposit, and third, the Wisconsin glaciation passed across this superposed valley. These relations are illustrated in Figure 3.

The case just discussed is believed to be the only one described in which there seems to be erosional evidence of three times of glaciation. However, if search were made for indications of this sort it might be that it would be possible to corroborate from the features of glacial erosion a considerable amount of the Pleistocene history which we know so well at present from the evidence provided in the areas of glacial deposition.

THE FARM CREEK EXPOSURE NEAR PEORIA, ILLINOIS—A TYPE PLEISTOCENE SECTION

MORRIS M. LEIGHTON, ILLINOIS GEOLOGICAL SURVEY, URBANA

INTRODUCTION

The Peorian interglacial stage was named by Leverett[1] on the basis of the relations of a body of loess to the Illinoian and Wisconsin drift sheets in certain exposures east of Peoria, Illinois. One of these was a stream-cut exposure along Farm Creek, 7 miles east of Peoria, and another a railway cut along the Toledo, Peoria and Western Railway, about half a mile farther east. Photographs of these cuts, taken by Doctor Calvin, are shown on Plate XI of Monograph XXXVIII, opposite page 128, and general descriptions are given in the legends and on pages 128 and 187, but no detailed description has been published, to the writer's knowledge, such as is desirable for type exposures.

In connection with Pleistocene investigations for the Illinois Geological Survey, the writer had occasion to visit these exposures during the field season of 1920. The railway cut was so badly slumped and grassed over that a study could not be made of it, but the Farm Creek exposure was in exceptionally good condition for inspection. A detailed description was, therefore, made, which includes some important points not heretofore recorded.

LOCATION

So far as can be determined from the post office map of Tazewell County, the Farm Creek exposure is located near the south line of the SE. ¼ sec. 30, T. 26 N., R. 3 W., on the south side of the stream just east of the Toledo, Peoria and Western Railway bridge. The small stream swings against the south valley wall at this place and undercuts actively enough to keep the face of the exposure fairly clean. At the time of visit the face was somewhat freer of slump than it was at the time the photograph, above referred to, was taken.

[1] Leverett, Frank: The Illinois Glacial Lobe, U. S. Geol. Survey, Monograph XXXVIII, 1899, p. 187.

DIMENSIONS AND FORMS

The cut is about 100 feet high, 225 feet long in an east-west direction, and, with the exception of minor details, it has about the same form as shown in the photograph by Dr. Calvin. The general form and sequence of materials is sketched in the accompanying diagram.

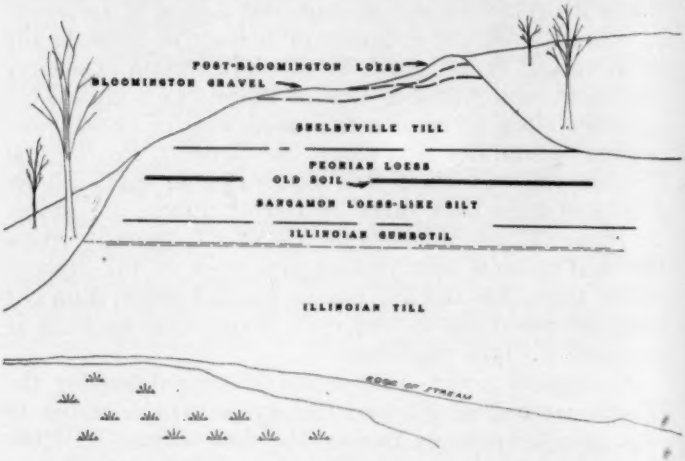


Fig. 1. The Stratigraphic Succession at the Farm Creek Exposure.

STRATIGRAPHIC SECTION

The following stratigraphic section is shown:

		Feet
Post Bloomington:		
8 c.	Soil, light gray, loessial	1-1½
8 b.	Leached loess, brown, jointed by roots and surface weathering, thickness about	3½
8 a.	Calcareous loess, yellow, no shells found, thickness	0-2½
Early Wisconsin:		
7.	Bloomington gravel, discontinuous, brown, limestone pebbles present beneath calcareous loess, absent for a few inches directly beneath leached loess, thickness	0-4
6.	Shelbyville till, typical pebbly clay till with lens of gravel 8-10 feet thick on east side, and about 10 feet below the top, the gravel contains till balls, till oxidized yellow in upper 2-6 feet with very faint maroon or orange tinge, bluish gray below where damp; light gray on dry surface, with slight maroon tinge, calcareous, thickness	32
Peorian:		
5.	Loess, grayish yellow, with rusty streaks and spots, fossiliferous, shells fragile and larger ones crushed and difficult to extricate, cleavage planes through the loess made by the pressure which crushed the shells, calcar-	

eous throughout, humus streak 2 inches thick about 10 inches below the Wisconsin till, contact with Shelbyville till sharp, thickness..... 6

Sangamon:

4. Old soil, dark with flakes of carbon, some fragments of old wood in east part of cut, loessial in texture, non-calcareous 1-1½

3. Loess-like silt, on east side brownish in upper 1-1½ feet, grading below into grayish yellow, 2-2½ feet, and again into brownish loess with carbon specks 3-4 feet, the lower 2 feet showing slight trace of effervescence with acid; no effervescence in the upper 5½ feet; no bedding or stratification. On west side this loess-like silt is bluish gray with greenish cast below the old soil; the soil and about 6 inches of the greenish loess is leached; calcareous below, very compact, no bedding or stratification, scattered small pebbles in lower 3 feet; thickness same on both sides of cut....7-8

Illinoian:

2. Gumbotil, chocolate brown, with reddish specks on east side, brownish to brick red at top with bluish-green spots on west side, tenaceous, hackly fracture, siliceous pebbles, mostly under ¾ inch, non-calcareous, shear zones on west side, thickness about..... 4

Grades into:

1. Till, very calcareous, few small lime concretions at top, limestone pebbles prevalent, grayish, mostly covered with wash and slump to base of cut..... 41

INTERPRETATIONS

Several important points are to be noted in the interpretation of this section.

1. There can be scarcely any doubt that the lower till is Illinoian in age. The typical Illinoian till occurs but a few miles to the south and southwest with its surface at the same elevation essentially as it is here, and with similar relations to the overlying loess.

South of the Wisconsin drift boundary, gumbotil has been found at the top of the Illinoian, and it is impressive to find it here. As pointed out by Kay and Pearce[1], this peculiar tenaceous, leached, and siliceous pebbly clay appears to be the product of a long interval of chemical weathering of the till before the deposition of the overlying deposit.

2. The overlying loess-like silt, horizon 3 of the section, seems best interpreted as a weathered loess. The color and weathered character of the Illinoian gumbotil below, and the thickness and calcareous content of the loess-like silt above exclude the interpretation that the

[1]Kay, G. F., and Pearce, J. Newton: The Origin of Gumbotil. Jour. Geol. Vol. XXVIII, No. 2 (1920), pp. 89-125.

latter is the product of extreme weathering of the gumbotil. The occurrence of rare pebbles in the lower part is not unusual to the basal portion of any loess deposit which rests on a pebbly formation from which pebbles could be introduced secondarily by organic agencies. The calcareousness of the lower part of this deposit, although not notable, indicates that it was deposited subsequent to the weathering of the gumbotil. The upper leached zone of 5½ feet, the brownish color on the east side of the cut, and the overlying old soil show that this loess-like silt was subjected to subaerial agencies of weathering and plant growth for a considerable period before the deposition of the overlying fossiliferous loess.

The presence of this soil zone and the loess-like silt beneath the fossiliferous loess has not been hitherto noted. In the legend of the photograph of the Farm Creek section in Monograph XXXVIII, Pl. XI, Leverett includes all of the deposits between the Illinoian till and the Wisconsin till as "Iowan loess".

In the railway cut, one-half mile to the east, Leverett reports and illustrates by photograph the occurrence of a peat bed, 3 to 5 feet thick, below the so-called Iowan loess, and a 2-to 5-foot bed of silt between the peat bed and the underlying Illinoian till[1]. Of the silt, Leverett states that it "bears some resemblance to the overlying Iowan loess in texture, but is not so calcareous and is of a deeper brown color. Whether it is similar in origin to the loess can scarcely be decided." Parenthetically, it may be stated that this monograph was written when the theory of the origin of the loess was swinging from the aqueous hypothesis to the eolian hypothesis, and the discussion carries the spirit of compromise, rather than the present general view that the loess is dominantly eolian in origin.

The peat of the railway cut occupies the same horizon as the old soil in the Farm Creek exposure. The peat here, as Leverett points out, records poor drainage conditions after the weathering of the underlying till. It may well have been a local marsh, such as might result if there were relatively slight irregularities in the deposition

[1]Leverett, Frank: The Illinois Glacial Lobe, U. S. Geol. Survey, Monograph XXXVIII, 1899, p. 128; Pl. XI. B.

of the loess on a previous flat surface. The Farm Creek exposure emphasizes the local transition that existed within a short distance from subsurface drainage of an oxidizing character to nearly stagnant drainage of either unoxidizing or deoxidizing character. The brown to grayish-yellow color of the old loess-like silt in the east part of the cut is believed to represent the former condition, while the bluish-gray loess-like silt with greenish cast in the west part represents the latter. The difference in color of this loess-like silt and the normal loess is, therefore, not significant of a difference in mode of origin.

The overlying soil was formed subsequent to the deposition of the underlying loess-like silt, before the deposition of the overlying loess. Whether its development represents the full period of time involved in the weathering of the underlying loess-like silt can not be denied or affirmed. It represents at least the latter part of this period, and plausibly coincides with the Sangamon soils known elsewhere which are reported to contain boreal vegetable remains. Such vegetation probably lived during the transition from the Sangamon interglacial epoch to the Iowan glacial epoch or even during the Iowan glacial epoch. The loess-like silt is also referred to the latter part of the Sangamon, and the silt of Leverett's railroad section is correlated with it.

3. Horizon No. 5 is typical fossiliferous loess. It contains *Helicina occulta* (Say), *Succinea ovalis* (Say), and *Oreohelix iowensis*, the shells of the latter crushed, but identifiable. These species are common to the Peorian loess but the first two are reported to occur also in recent loess. It is to be noted that the deposit is calcareous to the top, but the oxidized state is in harmony with the evidence at other places recorded by Leverett that an interval of weathering occurred between the deposition of the loess and the overlying Shelbyville till.

The two-inch layer of humus which occurs ten inches below the top of the loess records a cessation of wind deposition. Inasmuch as the writer does not recall any other exposure of Peorian loess—among the scores which he has seen—which shows a definite soil zone within the loess, he is inclined to the view that the soil represents

the latter part of the Peorian epoch, and that the overlying ten inches of loess was deposited during the oncoming of the Shelbyvile ice. The alternative view is that this soil occurs within the body of the Peoriian loess, recording two sub-epochs of loess deposition in the Peorian epoch, in which case there is the possibility that if there were a leached zone of the loess before the invasion of the early Wisconsin ice that this zone and a part of the calcareous zone were removed by the ice. In a recent report on "The Iowan Drift—a Review of the Evidences of the Iowan Stage of Glaciation", Alden and Leighton present the view that the great body of loess associated with the Iowan drift was deposited almost immediately following the recession of the Iowan ice sheet, but under sufficiently favorable climatic conditions to destroy the glacier and to permit the growth of vegetation and the existence of herbivorous snails[1]; in other words, the time of the loess deposition was referred to the early Peorian epoch.

If the first view outlined above is correct, the time of the deposition of the loess in the Farm Creek exposure is more closely connected with the Wisconsin glacial epoch than if the second view were found to be true. On the other hand, it is clear that the Peorian loess was deposited a long time after the deposition of the Illinoian drift.

4. The body of till at horizon No. 6 is unquestionably Early Wisconsin in age, and is clearly Shelbyville since the Bloomington moraine lies to the north of this locality.

5. The overlying gravel is probably outwash from the Bloomington ice, since it occurs above the till and has an elevation in accord with the Bloomington outwash at Peoria.

6. The loess above the Shelbyville till and the Bloomington gravel is not mentioned in the legend accompanying the photograph in Monograph XXXVIII, previously mentioned. Its thickness is from 4½ to 7 feet. The upper 4½ to 5 feet, including the soil, is noncalcareous, and where the noncalcareous portion rests on gravel, the gravel is partly leached. But where the loess is thicker than 5 feet, its base is calcareous and the gravel beneath

[1]Iowa Geological Survey, Vol. XXVI, Annual Report for 1915, pages 156-158.

is unleached. This shows that at least a part, if not all, of the loess was deposited in a calcareous state immediately after the retreat of the ice at a rate in excess of leaching, and that subsequently the rate of deposition of the loess either decreased or deposition ceased, giving opportunity for leaching to take place.

SUMMARY

This cut is remarkable in its display of evidence for two glacial epochs, the Illinoian and Wisconsin, and two interglacial epochs, the Sangamon and Peorian. Most of the varieties of interglacial evidence are present, including ordinary weathering, gumbotil development, loess deposits, and soil formation. Not only is the common Peorian loess present, but also the more or less local post-Wisconsin loess. Well deserving is the Farm Creek exposure—7 miles east of Peoria, Illinois—of a place among the type exposures of the Pleistocene of America.

COMPARISON OF THE DEVONIAN ROCKS OF ILLINOIS AND MISSOURI

T. E. Savage, University of Illinois

ABSTRACT

Certain areas in the states of Illinois and Missouri were parts of the same geologic province during Devonian time, and the Devonian history in these states was quite similar. In southwest Illinois and southeast Missouri the Bailey limestone of Helderbergian age has a similar development. The Oriskany limestone is represented in both areas by the Little Saline limestone, and in Illinois an older chert formation (Grassy Knob chert) of Oriskany age is also present. Onondaga strata are present in both states in the Grand Tower limestone, the lower part of which in Illinois and parts of Missouri includes the Clear Creek chert. The Lingle limestone in both states corresponds in age to the Hamilton of the New York section. The Alto formation in southwest Illinois is equivalent to some part of the Upper Devonian of New York, but no corresponding strata are present in southeastern Missouri. In central Missouri the Cooper, Mineola, and Calloway limestone are together about equivalent to the upper part of the Wapsipinicon and the Cedar Valley formations of northwest Illinois, and eastern Iowa. The Snyder Creek shale of Missouri corresponds somewhat closely with the Lime Creek shale of Iowa, but no equivalent strata are present in Illinois. The Mountain Glen shale of Illinois does not appear to be represented in Missouri.

THE OOLITE OF THE STE. GENEVIEVE FORMATION[1]

J. E. LAMAR, STATE GEOLOGICAL SURVEY, URBANA

The term oolite is derived from Greek words meaning egg and rock, and was suggested by the resemblance of a mass of oolite grains to the roe or eggs of fish. The word oolite is used to describe a rock made up of oolite grains to which the term spherules or spherites is applied. A spherule is defined as a concretion, commonly of calcium carbonate, with an internal radiating and concentric structure. The central nucleus of a spherule may be a foreign particle or may be of the same material as the oolite grain itself.

ORIGIN OF OOLITE

Two different modes of origin have been assigned to calcareous oolite, namely organic and inorganic. In the former case the oolite grains are thought to have resulted from the precipitation of calcium carbonate directly or indirectly by bacteria or algae. The bacteria or algae may have formed the center of the grain or have attached themselves to a foreign body which became the center around which the organisms caused a precipitation of calcium carbonate.

It has been stated that calcareous oolite of inorganic origin has been formed by the precipitation of calcium carbonate around minute particles of sand or other foreign bodies kept in motion so that all sides might become about equally encrusted. The spherical shape of the grains is supposed to have been due to rolling of the spherules on the sea bottom. Somewhat in contrast to this idea Bucher[2] is of the opinion that most oolitic grains were formed from a dispersion medium "by at least one constituent substance changing from the emulsoid state to that of a solid" and that "the spherical shape of the grains is due to the tendency of the droplets forming during this process of separation to coalesce." Further he ascribes the difference between the radial and concentric structure as depending "on

[1]Published by courtesy of the Chief, Illinois State Geological Survey.
[2]Bucher, W. H., On oolites and spherulites, Jour. Geol. V. 26, 1918, p. 602.

the amount of other substance thrown out simultaneously with and mechanically enmeshed in the growing structure."

In either of the cases mentioned in the above paragraph it would seem possible that organic remains might be trapped within oolite grains during their formation without actually playing a primary part in their development or growth.

THE STE. GENEVIEVE OOLITE

The Ste. Genevieve is the uppermost formation of the lower Mississippian system. It is exposed in the southern and western parts of Illinois and is in general a very pure limestone. The lithologic character of the formation varies both horizontally and vertically, but the presence of conspicuous beds of oolite is one feature which is widespread and constant. Locally this oolite is cross bedded. The spherules vary from a fraction of a millimeter to a maximum of about 2 millimeters in diameter, and are composed dominantly of calcium carbonate. Included with the calcium carbonate are small amounts of disseminated organic and argillaceous material. None of the sections of Ste. Genevieve oolite examined suggested an organic origin of the spherules and they are therefore thought to have been formed by inorganic means.

TYPES OF SPHERULES FOUND IN THE STE. GENEVIEVE FORMATION

The Ste. Genevieve oolite contains spherules in many different stages of development, and it is difficult to divide the forms into groups which will have a sharp line of demarcation. It is possible, however, to recognize three distinctly different types of spherules as follows: (1) those with an angular central grain, (2) those with a rounded central grain, and (3) those which show no distinct central grain.

The first type of spherule with an angular central grain is illustrated by the spherule near the center of Fig. 1 and by Fig. 2. In some spherules the central grains are surrounded by but one ring of calcium carbonate, but in

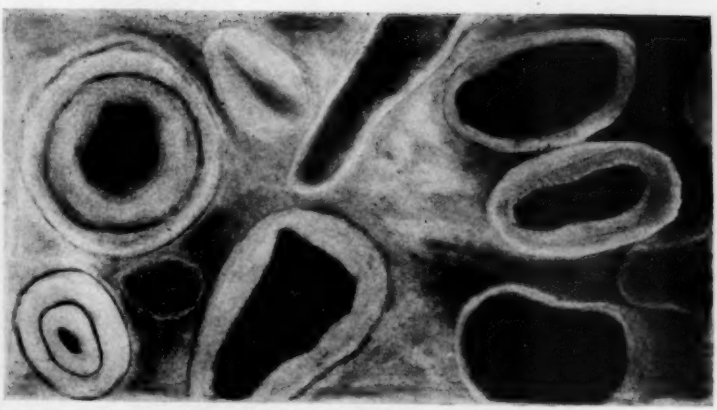


Fig. 1. Drawing of etched polished surface of oolite. Magnified about 50 times.

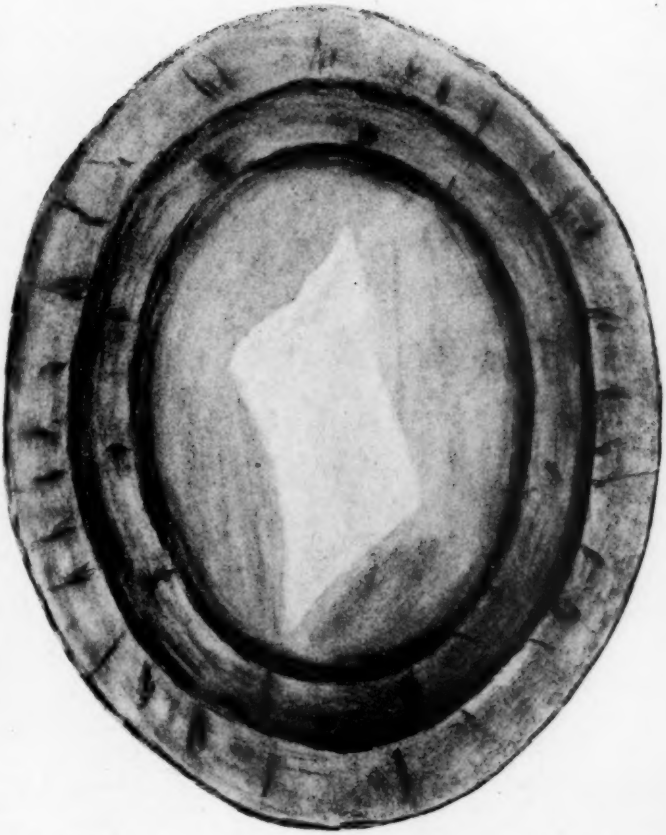


Fig. 2. Drawing of thin section of spherule of type 1. Magnified about 125 times.

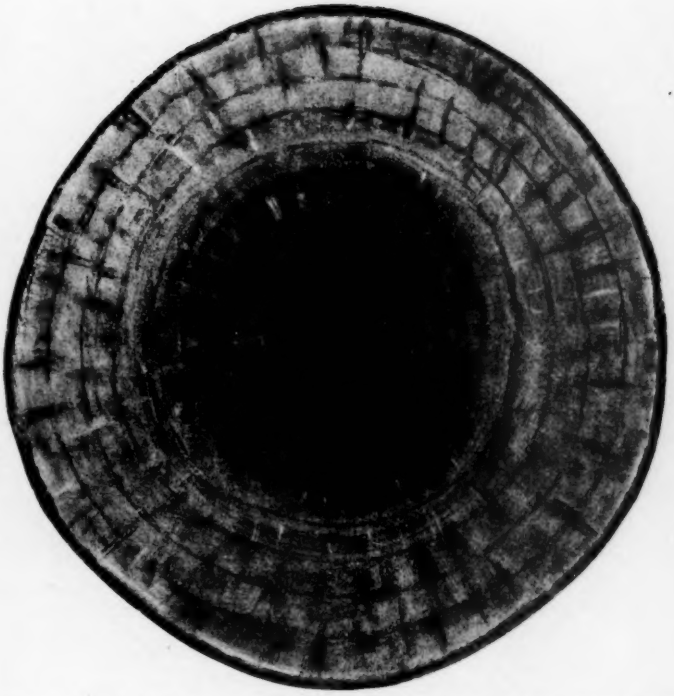


Fig. 3. Drawing of thin section of spherule of type 3. Magnified about 125 times

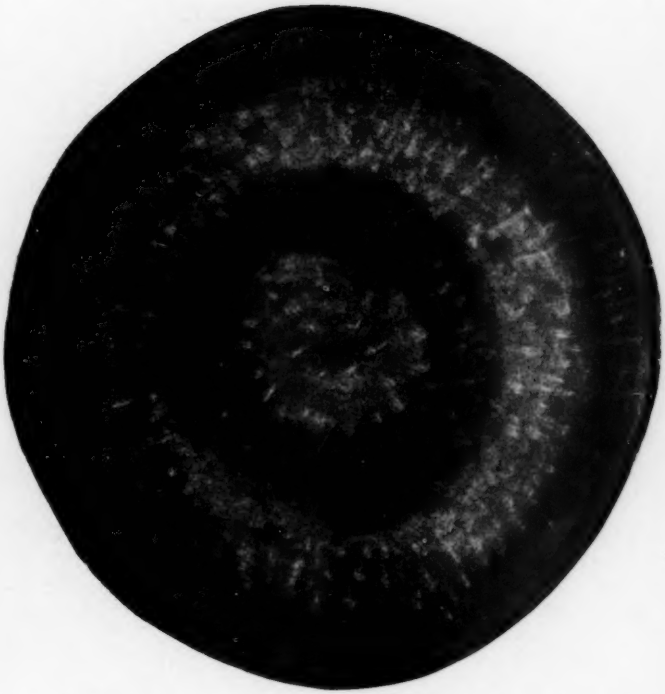


Fig. 4. Drawing of thin section of spherule of type 3. Magnified about 120 times.

Fig. 5. Drawing of thin section of oolite. Magnified about 50 times.

many four or five concentric deposits are present. As many as eight rings have been observed. A radiating structure is commonly present in the material composing the rings.

The second type of spherule with a rounded center is illustrated by four of the forms shown in Fig. 1. In many the centers are almost spherical but more commonly they are ovoid and somewhat elongated. A maximum of nine concentric deposits of calcium carbonate have been noted around rounded central grains and in general a radiating structure is exhibited by the material composing the rings.

The third type of spherule, characterized by the lack of a distinct central grain, is shown in Figs. 3 and 4. Figure 3 shows a form with the concentric and radiating structure well developed and Fig. 4 a spherule in which there is but a slight suggestion of these structures. There are all gradations between these two sorts of spherules. Eleven distinct rings were noted in a spherule of this type and in general they are the more annular of the types described.

THE CENTRAL GRAINS

There are two classes of central grains which may be recognized. The first is illustrated in Fig. 5, and is thought to have been formed by the recrystallization of the calcium carbonate forming the amorphous centers of spherules of the third type such as is shown in Fig. 3. During the recrystallization, the argillaceous or organic material included in the original center was excluded from the growing crystalline center and formed the conspicuous dark ring around the central grain as shown in Fig. 5. These grains were slightly more rapidly soluble in hydrochloric acid than the concentric deposits about them. In the case of the central grain of Fig. 2, it may have been formed in the same manner as the preceding, but the absence of the dark band around the center suggests that either the primary amorphous center was very pure or else the spherule has resulted from the accretion of calcium carbonate around an angular calcite grain.

The second class of central grains is shown in Fig. 1, which is an enlarged sketch made from a photomicro-

graph of a piece of oolite with a polished surface which was etched with hydrochloric acid. This etching resulted in a more rapid solution of the material surrounding the central grains than of the grains themselves, thus leaving the centers standing as slight projections above the general level of the smoothed surface. The centers are composed of calcium carbonate and also the rings surrounding them, for the specimen was entirely soluble in acid with but a very slight residue. The Ste. Genevieve formation is in parts made up entirely of more or less rounded detrital particles and fragments of shells and tests, some of which still exhibit recognizable structures, and the second type of centers are thought to be such fragments. In some oolites recognizable shell and bryozoa fragments have been noted as spherule centers. The calcium carbonate forming the concentric deposits around these centers may possibly collect around them in the manner suggested under the first mentioned mode of formation of oolitic grains.

SUGGESTIONS AS TO CONDITIONS OF SEDIMENTATION DURING THE FORMATION OF STE. GENEVIEVE OOLITE

One of the outstanding features which a study of the limestones of the Ste. Genevieve formation brings out is the large amount of detrital calcareous material which is associated with the oolite of the formation or is present in beds in which oolitic grains are essentially missing or uncommon. A great deal of this detritus is doubtless derived from the comminution of calcareous tests. A part of it, however, may have been obtained from limestone adjacent to the site of deposition subject to active erosion with comparatively small amount of transportation. This is suggested by what appear in thin sections to be fragments of limestone. One was noted which contained within it two well formed spherules and a form suggestive of a fragment of a crinoid stem. The association of oolite grains and calcareous detritus, the presence of fragments of limestone, taken together with the cross bedding found in places in the Ste. Genevieve formation, suggest comparatively shallow water conditions, where erosion and transportation were relatively

active. The question is raised as to whether the spherules as found have been formed in situ or whether in the deeper waters somewhat distant from the shore, there may not have been an oolite-forming zone where spherules were constantly forming, to be carried shoreward during storms and rough water, there to be commingled with the calcareous sands of the sea beaches, bars, and shore. The thin section from which Fig. 5 is drawn contains no calcareous debris other than a few gastropod shells which show very little evidence of erosion or abrasion. This absence of debris and the development of projections from the outer concentric bands of the spherules suggest conditions favoring uninterrupted growth of the spherules. This section may, therefore, represent the deposits of primary oolite of the oolite-forming zone.

In contrast with the preceding suggestion that oolite may be formed in off shore zones, it may be pointed out that a beach subject to tidal inundation and subsequent withdrawal might well offer a favorable site for the accumulation of calcium carbonate around sand grains, both calcareous and siliceous. The re-working of such a deposit by contemporaneous or later currents without much abrasion may account for the varied occurrences of the spherules.

LANTERN SLIDE EXAMINATIONS IN GEOLOGY

F. P. Shepard, University of Illinois

In teaching geology to students who live in a region where the surrounding country lacks features of geological interest, lantern slides are especially helpful to an instructor. If one of the main purposes of an elementary course in geology is to teach the students to appreciate the geological significance of scenic features, then an examination should be constructed in such a way as to test the ability of the class to interpret such features. Ordinary examination questions do not test this observational knowledge, but rather test the memory of the student for definitions. To know a definition unfortunately does not always include knowing how to apply it. By using a carefully selected series of lantern slides, the actual ability of the class to appreciate geology as shown in the field can be tested readily. A series of examinations of this sort have been given by the writer and two other members of the department at the University of Illinois during the last two years. The results have proved increasingly satisfactory with each examination.

It must be borne in mind that the average student has little idea of dimensions in pictures and needs practice in learning to discriminate various objects on the screen. Lantern slide examinations are probably only advisable if the students have been instructed by the use of lantern slides on frequent occasions during the course. At the University of Illinois, a daylight lantern is used which can be operated by the instructor from the front of the room. The lantern reflects on a mirror set back in the wall and out to a ground glass screen set in the blackboard just above the lantern (Fig. 1). Slides are available in a case next to the lantern and can be used at any time the instructor wishes without loss of time. This system saves the instructor much time and energy which would be lost by drawing on the board. Also the pictures are in most cases more effective than a sketch as illustrations.

Fig. 2. Give a complete sequence of events which could lead to the development of this rock column.

Fig. 3. Has this valley been glaciated?

Fig. 4. What is the age of valley development illustrated in this photograph?

Fig. 5 . What evidences, if any, suggest a former greater extent of the glaciers in this region?

Fig. 6. This comparatively flat surface is at an elevation of 12,000 feet. The rock is crystalline. What is the geological significance of such a surface?

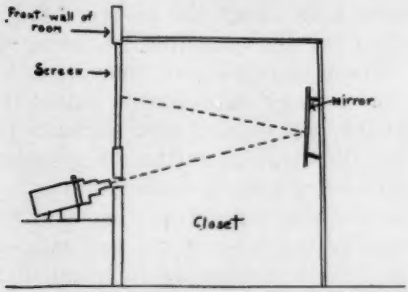


Fig. 1. Arrangement of daylight lantern devised by T. T. Quirke.

The type of question to use and the type of picture depend on two things; first, the amount of practice the students have had in class work with lantern slides, and second, the amount of field work that has been given in the course. If the field work is limited because of uninteresting areas, but lantern slides have been shown frequently, the photographs reproduced here are examples of the types used with questions which may prove satisfactory. The question with Figure 2 gives the student a chance for considerable application of knowledge because stratification suggests deposition, probably in the ocean; the present relief suggests uplift; the protruding layer shows difference of resistance in the weathering; and the shape of the column suggests that wind erosion helped to produce this feature. Figures 3 and 4 are simple tests of memory and application. Figure 5 requires more accurate observation in order to see all of the points such as the cirque, the U-shaped valley, the hanging valleys, and the lake. The uplifted peneplain in Figure 6 would probably mean nothing to the student who relied merely on text book definitions. The purpose of such a picture as Figure 7 is to give the keener type of student a chance to show his ability. Students, who have no trouble in determining that the boulders are from a landslide, in most cases attribute the killing of the trees to the landslide. Figure 8 is perhaps less certain as to interpretation than the others, but is a feature which many students will see and should learn to understand.

Some of the advantages obtained by the picture examination are as follows:

1. Examinations become more interesting and less tedious to the student.

2. Students look at all the pictures they can secure in preparation for the examination, using a variety of textbooks. These pictures give them a much greater appreciation for geology than can be obtained by reading alone. Probably the majority of students pay little attention to the illustrations in their textbooks if they expect the ordinary system of examination.

3. If it is true that a good memory is all that is necessary to obtain high grades in the majority of university courses, then this system gives the student with originality a chance to compete with one who has a better memory. This has been seen to work in many cases. "A" students have received as low as "C" on these examinations. Those students who show ability at clear thinking in class recitations invariably do well on the examination.

4. If an instructor wishes to avoid long rambling answers to examination questions, this method should recommend itself since many of the questions need but a few words to be answered. The examination tests geological knowledge and not rhetoric.

The reaction of the students to these examinations was tested by asking them to write criticisms of the system giving them to understand that these would not be read till their grades were recorded. What appear to be genuine opinions were obtained in this way. About 65% approved of the picture exams, 14% liked some features and disliked others, and the remaining 21% disapproved. As might be expected, those who disapproved were in most cases those who did badly in the examinations, but there were a few exceptions.

Some of the comments are perhaps worth noting. Among those who did not approve, one considered that it was too hard for elementary students to learn to apply their knowledge, since it took enough of their time to learn the theories. Another thought that the general low grades of "A" students in the mid-semester examinations proved that it was not a fair test. A few thought that the picture tests should not be graded early in the semester, but were perfectly fair for a final examination. Of those who approved, reasons ranged everywhere from

Fig. 7. There is a steep slope to the left of the view shown here. Tell what has happened including the history of the trees in your account.

Fig. 8. This rock is sandstone. Account for its wall like appearance.

considering the examinations were easier and more interesting to the thought that it was a real test of knowledge. One man gave the following opinion: "I like this type of examination because I believe that it shows a practical application of the course and gives a chance for real thought and ingenuity."

PAPERS ON MEDICINE AND PUBLIC HEALTH

PUBLIC HEALTH EDUCATION IN RETROSPECT

BAXTER K. RICHARDSON, DEPARTMENT OF PUBLIC HEALTH, SPRINGFIELD

When King Tut reigned in Egypt the male sex married at 13 or 14 and the girls at 12 years of age. This was necessary in order for the parties concerned to enjoy an appreciable period of conjugal existence because the life span was exceedingly short in those ancient days. King Tut himself died a very young man.

At the time when Queen Elizabeth graced the British throne a man who survived thirty summers of that stirring romantic age was no less an exception to the general rule than the centenarian is today. As late as 1800 the average length of human life was less than 25 years, but it had risen to 45 by the opening of the twentieth century. Now, in the United States, a child at birth, if he can be identified as that illusive character, the average person, may look forward to an after existence of 58 years on this earth.

The law of cause and effect has operated to bring about this marvelous transformation whereby the years of man are not only extended to more than double their former number but are made infinitely more healthy and happy. As one authority expresses it, "In twenty-four years we have accomplished more in medicine than in twenty-four centuries before."

The change that has taken place has been both negative and positive in character. Quackery and the sale of nostrums in their worst forms have been eliminated, while the advancement in medical and sanitary knowledge has been accompanied by the development of public and private agencies devoted to the purpose of controlling and preventing diseases.

To understand of what moment are the things that have transpired during the past fifty years one needs but to give a hasty glance at the history of the Illinois State Department of Public Health and dwell for an instant upon a few outstanding features of that history.

In 1877, not yet 50 years ago, the Illinois State Board of Health was created by an act of the legislature. Com-

menting on that event, which was certainly a manifestation of public concern in matters of health, the Chicago Tribune, on November 21, 1877, said:

"The State Board of Health is of recent invention. The last Legislature, in its infinite wisdom, saw fit to create this new board. By some it has been thought to be an unnecessary luxury and by others an actual necessity. One of its principal duties is to obtain a registry of all the physicians in the state who are entitled to practice and who are graduates of medical colleges, and to issue to them a certificate showing that they have either passed the necessary examination, or shown ample proof that they are physicians in good standing, entitled to the sheepskins which they profess to own. So far, the Board is a benefit to the public, and it will materially aid in wiping out the quacks, who have settled themselves all over the State."

From the December 17, 1877, edition of the Inter-Ocean, a Chicago daily, is the following extract:

"It is hardly necessary to say that the city of Chicago has become noted, not only for the immense number of villainous quacks, but for the ignorant and imperfect manner in which the register of births and deaths has been kept. The infant who was reported as having died of 'canker rash, diphtheria, dysentery and consumption,' and another, whose cause of death was returned as 'five doctors,' doubtless had good reasons to die; and 'delicate from birth,' 'infancy,' 'stoppage,' 'fits,' 'colerafantum,' 'collocinphanton,' 'cholry fanton,' 'bled,' 'direars' (diarrhea), 'billirm (delirium) fever,' 'artry lung busted,' 'feusson' (effusion), 'canker on brane,' and 'infermation lungs,' probably convey some ideas to the persons who wrote the terms; but such returns cannot be of much use from a statistical point of view. The importance of correct and intelligent registration cannot be underestimated, as modern sanitary science owes its existence to the registration of deaths and the localization thereby of insanitary conditions. It is right that the enforcement of the two bills, passed by the Legislature of the State, that will make such a radical change both in medical profession and in the method of registering births and deaths, should demand considerable attention."

These quotations suggest the deplorable conditions into which the practice of medicine had fallen fifty years ago in Illinois. Anybody who desired to become a "doctor" had only to open an office, hang out his shingle and bid for clients. There was none to hinder him and his success depended only upon his ability to attract patients. Short course and fake medical institutions sprang up and flourished. In many quarters the business of making and being "doctors" was looked upon as a lucrative vocation rather than as a high and dignified calling to a noble service for the alleviation and prevention of human ills.

Of course the quack is still with us, but he is more refined and fairly well regulated. His range of mischief is more limited. He cannot prescribe drugs. He must secure a state license. The public understand that the term "doctor" does not necessarily imply "M. D." Most folks know to whom they must turn when real medical advice or service is desired.

OTHER SERVICE OF THE BOARD OF HEALTH

Serious as it was, the "quack" problem made up but a part of the duties ascribed to the State Board of Health. Epidemic and pestilential diseases stalked to and fro in the land. The Board of Health was required and given authority to employ whatever measures were deemed necessary in the abatement and prevention of such diseases. Section 2 of the original law of 1877 reads, in part, as follows:

"The State Board of Health shall have the general supervision of the interests of the health and lives of the people of the State. They shall have supreme authority in matters of quarantine, and may declare and enforce quarantine when none exists, and may modify or relax quarantine when it has been established. The Board shall have authority to make such rules and regulations and such sanitary investigations as they may from time to time deem necessary for the preservation and improvement of the public health, and they are impowered to regulate the transportation of the remains of deceased persons."

Under this provision the Board of Health, during the second year of its existence, was called upon to deal with a terrifying epidemic of yellow fever. During the summer of 1878 the disease broke out in New Orleans. This was no uncommon occurrence, but the outbreak suddenly assumed such serious and fatal proportions that the population fled from New Orleans like rats from a burning vessel. The refugees were unwelcomed guests in Northern territory. The disease soon began to work its way up the Mississippi Valley and to appear in the same deadly form among the inhabitants of the river towns. Like some invisible beast it crept from town to town, reaching its terrible fangs into the homes of both rich and poor, striking terror into the hearts of everyone. Whole cities were depopulated overnight except for the sick and the courageous doctors and nurses who ministered to their needs. The disease travelled as far north as Cairo, Illinois, where it caused scores of cases of illness and resulted in 62 fatalities.

The following quotation from the August 14, 1878, edition of the Chicago Times indicates the frightful state of affairs that prevailed in Grenada, Mississippi:

"There have been seven deaths from fever and eight new cases in the last twenty-four hours. The indications are that at least eight or ten more will die before noon tomorrow. So far, none have got well. The town is in a filthy condition. The sewers are open in many places, and garbage lies around uncovered. Disinfectants are now freely used. At least five hundred white people, out of a population of twelve hundred white citizens, have left town, They are certainly not to be blamed. Only one colored person has been taken down so far. It appears to strike the best citizens of the place. Dr. Hughes reports four cases of black vomit that will die tonight undoubtedly. The weather is very unfavorable for the patients. It is cloudy and threatening rain. All excepting the drug stores are closed. No train is allowed to stop and supplies are getting scarce. The condition of affairs here is truly appalling."

Another newspaper dispatch, quoted from the August 16, 1878, issue of the Chicago Tribune sheds more light

upon the distress at Grenada. It was a copy of a telegram to the Mayor of Wilmington, N. C., and reads as follows:

"Grenada, Miss., Aug. 14, 1878.—To the Mayor of Wilmington: Help us to pay nurses and bury the dead. Our town is a graveyard. We need help. The Mayor is dying, and I am the only officer left.

E. D. A. Molton,
City Marshall,
Acting Mayor."

Conditions were much the same in Memphis, while in New Orleans every ordinary social and business activity was completely demoralized if not entirely paralyzed.

People of Illinois were in a state of alarm lest the yellow fever plague should fasten itself upon the state. Chicago newspapers carried the harrowing details of the epidemic under such compelling head-lines as:

JUNGLE JACK

His Summer Tour in the North to be opposed at Every Step.

THE FANGS OF FEVER

Fastened on Two More Dwellers in Cincinnati Yesterday.

NEARING THE NORTH

The Yellow Fever's Progress Up the Mississippi Valley Unimpeded.

THE AWFUL ARCHER

His Victims Still Falling by the Score in the Fever District.

THE DENS OF DEATH

Railway Trains Unchecked in Their Flight Past the Plague Spot.

THE MOWER OF MEN

Progress of Yellow Jack's Harvest of Humanity at the South.

Nobody in the whole Mississippi Valley or in territory contiguous to the Gulf coast felt safe from yellow fever. Nobody knew how the deadly plague was spread so that everyone stood in constant fear and dread of every person and everything that came from the fever district. Everything was suspected of harboring the germs of the dreadful disease that had already worked such havoc in the main foci of infection. As indicative of the state of knowledge about the cause of yellow fever a few paragraphs from instructions sent out by the Surgeon General of the U. S. Public Health Service are quoted. As they appeared in the August 20, 1878, edition of the Chicago Times, we read:

"The weight of scientific evidence seems to warrant the conclusion that yellow fever is produced by an invisible poison, capable of self-multiplication outside of the human organism, which it enters through the air passages. The poison germ or miasm is a product of the tropics. In this country yellow fever has prevailed in most of the Gulf and Atlantic cities, and in many of the towns along the Mississippi River. In some instances it has been carried inland with the people fleeing from infected localities, but it has never shown a disposition to spread epidemically at points remote from the continuous water-roads of commerce, or to lodge in high, salubrious places. The cities of the Great Lakes have always been free from the disease. Yellow fever cannot be said to be endemic in the United States, from the fact that in some years it does not appear, though the imported germ undoubtedly survives the mild winters.

It appears to have about as much resistance of cold as the banana plant. When the banana stalk is killed

down by the frost the yellow fever does not recur again until imported. The germ is transmissible. It is capable of being transported to the clothing or personal effects of passengers and sailors, but its spread from one city to another is chiefly accomplished by vessels, their damp, filthy holds and bilge water being its favorite lurking-places. Confinement, moisture, and high temperature favor the multiplication or virulence of the poison."

People looked with suspicion upon the earth, vegetation, the sunshine and the air. This is demonstrated by the following paragraph from the Cairo (Illinois) Bulletin, dated August 2, 1878:

"Great care should be taken not to root up vegetable matter, or uncover heaps of mould, or remove pavements during this season. These are the lurking places of bacteria, vibriones, and fungi. It is safer to apply the antiseptics to them as they are than to expose their miasmatic underlying to the sun."

A similar slant is evidenced from the minutes of the meetings of the State Board of Health. From a chapter of those official records relating to the proposed inauguration of a most exhaustive sanitary and drainage campaign we read:

"In such study there must, of necessity, be a careful and thorough consideration of measures that will prevent not only the periodic overflows which occur almost every year, sowing the seeds of disease and death throughout the entire lower country, but of measures that will go yet further, and, through a comprehensive, skillfully planned system of drainage, will make dry the swamps and marshy places, and reclaim the millions of acres of valuable land that today remain more or less submerged as they were left by the aborigines, giving off continually noxious gases which, in their effects, are annually consigning thousands to premature graves, and at the same time placing the health of the whole people upon a lower plane than it would otherwise occupy, diminishing thereby their powers of resisting disease and enabling epidemics, as a consequence, to count their victims in greater numbers."

Even railroad cars and boats were regarded as carriers of yellow fever. So firmly were Pullman cars suspected

that the State Board of Health took measures not only to require the most thorough disinfection of cars that came from the epidemic districts but to prohibit them from entering Illinois at all. In the course of investigating Pullman cars a report from the superintendent of the Louisville and Nashville Railroad lines was received and incorporated in the minutes of the Board meeting. It reads, in part, as follows:

"In contracting our lines as the disease manifested itself in Memphis and other points south, in the latter part of July and the early part of August, all lines whose northern termini were in this city (Louisville) were entirely withdrawn, and thenceforward, until after the Board of Health had declared it safe for citizens to return to Memphis, not a single sleeping car coming from an infected district came into this city; the cars on the line from New Orleans to Cincinnati passed around the city by the short line cut-off, leaving the main stem of the Louisville and Nashville railroads three miles south of the city."

Another idea of how yellow fever spread north from New Orleans is gained from a dispatch which appeared in the August 15, 1878, edition of the Chicago Tribune. This conviction explains why refugees from the infected cities spread fear and alarm among the people in communities to which they fled. The dispatch reads:

"It is now definitely known that the fever was communicated to the Mississippi towns in the clothing of a boatman of the first boat that stopped at Memphis. This is one of the most dangerous means of spreading diseases, as well persons fleeing to the Northern cities can readily carry the poison."

Another newspaper quotation, describing the public alarm created by the appearance of a case of yellow fever in Cincinnati, gives a vivid picture of the state of the public mind in regard to that disease. The dispatch is taken from the August 1, 1878, edition of the Chicago Times and reads:

"Last Saturday morning a couple of guests registered at the Grand Hotel as 'William Hines and wife, New Orleans, Louisana.' They were just from the train, and

the gentleman, who, as it was afterward learned, is a very wealthy cotton broker of the Crescent city, appeared very ill. The lady, a most beautiful woman of perhaps 35 years, appeared to be very nervous and ill at ease, and it was plain to be seen that her condition arose from her solicitude for the welfare of her husband. In response to their request, the best apartments in the hotel were assigned them, and as quickly as possible the gentleman was placed in bed, and a physician summoned. Dr. Reamy, whose office is directly opposite the hotel, was soon at the bedside of the patient, but he found considerable difficulty in diagnosing the disease that he was called upon to grapple with. The wife, however, afforded him light on the subject without hesitation, saying that she was positive that Mr. Hines was a victim of that terrible scourge now raging with such virulence in New Orleans, Vicksburg, and other southern cities, yellow fever. Dr. Reamy was disposed to doubt the truth of her assertion but Mrs. Hines declared her conviction that it was yellow fever and nothing else; that she had been afflicted with the disease herself, and that while at home they had been exposed to it, and their presence at this time in Cincinnati was due to the fact that they came north with the especial purpose of getting beyond its reach.

Finally other physicians were called in, among them Dr. Tom Minor, the health officer. The result of this consultation was that it was a clear and pronounced case of the fell disease, though not what might be called a 'bad case'. Of course Col. Gilmour, the proprietor of the Grand, was not long in finding out that he had beneath his roof a man afflicted with a disorder as much to be feared and dreaded as is the smallpox, and, as a matter of course, he was in a fever of excitement. The news spread in some inexplicable way, and it was not many hours until a sort of panic reigned, where a few short hours before all was ease and enjoyment. Dr. Minor saw at once that his duty was to remove the patient to the city hospital, and this he at once made arrangements to do. Going to the hospital he explained the case to Col. Jones, the superintendent, and that official was horror-stricken at the idea of admitting within his door a victim

of the scourge. He protested against it with vehemence, but after a great deal of persuasion and not a little plain language on the part of the health officer he finally gave in."

The extent to which fear of yellow fever found lodgement is indicated by quarantine regulations adopted against that disease. Subsequent to the epidemic in New Orleans that city adopted regulations which included:

"In the event of any cases of fever breaking out in the city from germs hibernating from the last epidemic, each case will be kept under strict surveillance, and ingress and egress from the house where such case occurs will be prevented by a cordon of sanitary police, so as to prevent the spread of the disease."

A national Board of Health was created which drew up a most far reaching plan for sanitary control, including drainage of great areas along the Mississippi Valley, and for an interstate sanitary police system which would be clothed with great power. In behalf of this plan the president of the Illinois State Board of Health made an eloquent plea, closing with the impressive statement:

"Then will be dispelled, and then only, this deadly malaria which ever hangs like a heavy cloud over the entire Mississippi Valley, acting as a great clog to the energies of its inhabitants, and undermining the constitutions of all."

In connection with the yellow fever epidemic of 1878 the Illinois Board of Health was very active. It kept sanitary and medical officers at Cairo constantly. It participated in all the inter-state activities of importance which had a bearing upon the situation. It established quarantine regulations that required the inspection of all transportation equipment that came into the state from the south, including river boats. It worked untiringly and was responsible for controlling and allaying much of the alarm that smoldered in the minds of the whole population.

OTHER DISEASES

Yellow fever was not, of course, the only disease that ravaged upon the public and indeed it was not the chief

one in Illinois. It merely held the center of the stage for some years immediately following the creation of the Illinois Board of Health. Typhoid fever, tuberculosis, diphtheria, smallpox, scarlet fever were all far more deadly and far more prevalent in the state than yellow fever ever was.

As if prophetic of what was about to happen in Chicago, the Inter-Ocean carried, in the December 19, 1877, issue, a long discussion of the danger to that city from smallpox. In the course of the discussion it pointed out what had already occurred elsewhere, which, one may believe was sad enough, judging from the excerpt that reads:

"To show what the result of these deficiencies in the health department of Milwaukee have resulted in, it may be stated that during the past two years that city, with only a population of 80,000, has had nearly 5,000 cases of smallpox, 700 of which resulted in death. The city has at last arrived at some sense of its condition and it is now constructing a temporary smallpox hospital as fast as it can be built. In Montreal, a city not much over one-third as large as Chicago, and which, also, has no smallpox hospital and no compulsory vaccination law, the death rate from smallpox averaged 700 per annum."

A year later a most deadly and devastating epidemic of smallpox broke out in Chicago. It reached its crest in 1881 and raged on through 1882, causing 1180 deaths the first and 1292 deaths during the second of these two years. The death rate per 100,000 population from smallpox mounted to 218 and 230 for the two years respectively. Doubtless conditions were but little better in much of the down-state territory, although there are no statistics to bear out this assumption.

Eight years later in 1890, Chicago found itself in the throes of a typhoid fever epidemic of major propositions. It raged relentlessly for three long years causing 1008, 1997 and 1489 deaths during 1890, 1891 and 1892 respectively. This situation caused no such alarm and terrorism as an outbreak of yellow fever because typhoid fever was always present and these three unhappy years were merely worse than usual.

Examples like these could be multiplied at length both in regard to the diseases named and in regard to others such as diphtheria, scarlet fever, tuberculosis, rabies. The story would be all the more tragic if statistics were available for the entire state.

Contrast the foregoing with present day conditions. No case of yellow fever has been reported in the United States for a number of years. If the disease were to appear, and it is still a potential danger to the southern states, no wide-spread alarm would result because speedy measures for absolute control would be promptly introduced.

The 1923 death rate from smallpox in Illinois was less than 1/10 of 1 per 100,000. There were only 1450 cases of typhoid fever with less than 300 deaths in Illinois last year. The general death rate was 11.2 per 1000.

The change has resulted from a widening of real scientific medical knowledge. High school boys today know more about medical and sanitary facts than did practitioners of the healing art 100 years ago.

On the other hand there is still a long way to go. Diphtheria is a positively preventable disease. Toxin-antitoxin will make children immune to it. Why then do we still suffer therefrom? An average of more than 10,000 cases are reported annually to the state health authorities; an average of 1000 per year terminate fatally. The simple truth is that parents have not yet believed in their hearts that toxin-antitoxin is less dangerous than diphtheria.

Tuberculosis is still a problem. Pneumonia is just as deadly as it ever was. Mortality from heart diseases and cancer has increased. All of these maladies are subject to preventive and control measures. Progress toward preventing these and other diseases depends more largely upon the dissemination and popular application of scientific medical knowledge already available than upon the results of further researches in this field.

THE PREVALENCE OF GOITER IN ILLINOIS

Dr. J. Howard Beard, Health Service, University of Illinois

Simple goiter was noted by writers long before the Christian Era. Hindu records of 2000 B. C. describe thyroid enlargement. Confucius knew of it. The Egyptian, Greek and Roman physicians studied its clinical manifestations and left observations concerning swollen neck. Goiter has been known to exist as an endemic disease in the Alps since the time of Pliny. Marco Polo reported its presence in Central Asia in the thirteenth century.

The home of this disease on the continent of Europe is in Switzerland, but it is also prevalent in Austria, Spain, France, Germany, Russia and the Scandinavian Peninsula. The magnesium-limestone district of England has long been noted for the enlargement of the thyroid gland, which is known there as "Derbyshire neck." Asia, Africa and South America have their centers of this disease.

In Canada the malady is by no means infrequent in the Province of Quebec and in the city of Montreal. It is very common in the limestone regions at the end of Lake Ontario in the Province of Ontario. The early explorers of the Great Lakes frequently reported its occurrence among the Indians inhabiting their shores. In this locality its greatest prevalence tends to be co-incident with the hard water of the Niagara limestone. There are definite goiter areas in Oregon, Montana, Nevada, and Colorado. In fact, from the Atlantic to the Pacific and from the Great Lakes to the Gulf of Mexico there are sections of the country in which endemic goiter is prevalent.

Goiter is characterized by the enlargement of the thyroid gland, which occupies the lower portion of the neck anterior-laterally. There are two forms of this condition: simple goiter which is primarily a swelling of this gland, and exopthalmic goiter accompanied by the distention of the eyeballs, anemia, overactivity of the heart, tremor, muscle weakness, mental instability, and general organic disturbance.

The thyroid tends to enlarge during adolescence, but the great variation in its incidence in different localities and even in adjacent communities excludes age as the decisive factor. Its wide prevalence in children and in mature individuals in certain districts also discounts the influence of age. Goiter distribution points to an environmental cause which is now known to be a lack of iodine in water, soil, and food.

DISTRIBUTION IN ILLINOIS

On the basis of the total of 15,154 physical examinations, of which 10,829 were men and 4,325 were women high school graduates distributed over Illinois, it was found that the mean average of thyroid enlargement of the women for the five year period was 24.5%; the men, 4.6%. The attempt is made herewith to indicate the prevalence of endemic goiter in this state. Special considerations are presented in connection with its distribution.

The statistics presented are based upon the work of forty or more well-trained doctors, experienced in the making of physical examinations. While standard forms were used and definite directions were given, no attempt was made to direct special attention to the thyroid gland. The data is therefore more valuable, because it presents the concensus of opinion uninfluenced by over-emphasis or undue concentration upon a particular condition. It does, I believe, under rather than over-estimate the existence of simple thyroid enlargement in this state.

To show its relative prevalence in certain districts of Illinois the state was divided into three sections by irregular lines through the county boundaries from east to west, and into two parts by similar lines from north to south. Comparison of the incidence of goiter in men and in women in the divisions produced is shown in Table I.

TABLE I.

Incidents of Goiter in Certain Portions of the State.

	Women	Men	Total % of total number
	%	%	
North Section	43.5	9.6	21.2
Middle Section	36.7	6.7	13.1
South Section	27.8	5.2	12.4
East Section	31.1	5.5	17.0
West Section	39.6	8.2	15.2

These arbitrary divisions are interesting, because they show that the occurrence of thyroid enlargement, taking men and women together, tends to decrease from north to south and from east to west. While the directional tendency of reduction is definite, its explanation is not obvious. The decrease in prevalence with the increase in distance from the Great Lakes may indicate geological formation influencing iodine availability. In the comparison of goiter incidence in the east and west divisions of the state, the explanation would seem equally logical. It is seen by the Table that when men and women are separated in the east and west sections, the decrease runs from west to east. The change is due to the fact that three times as many students come to the University from the east side of the state. The percentage of the total number having thyroid is the more valuable figure in showing a comparison of the different sections of the state.

The state was also separated into fifteen sections by tiers of counties running east and west, and a curve plotted for men and women on the basis of the percentage of occurrence of thyroid enlargement. The result was an irregular curve, much alike for men and women but not entirely so. The following may be noted from Table II:

a. The usual marked disproportion in prevalence in men and in women.

b. Generally, wherever there is an increase or decrease in men in any tier, there is a similar increase or decrease in women, and vice versa, as would be expected where the same factors are operative in the case of both men and women.

c. In certain tiers, particularly in the southern part of the state, this similarity between incidence in men

and in women disappears. Here are found instances in which a rise in the prevalence in women may be followed by a fall in that in the case of men, or vice versa.

d. The drop of both men and women in tier No. 2 including Cook County may be an expression of the influences of iodine containing food shipped in from the outside.

e. With the exception of the tier including Cook County, the population per square mile shows considerable similarity to the goiter incidence in men and women. This is true until the southern part of the state is reached.

f. The variation in the lines of prevalence of goiter in men and women and the population density by the tiers of counties in the southern part of the state is disproportionately influenced by the small number examined and the relative importance of the presence or absence of enlarged thyroid in a few individuals.

TABLE II.

The Occurrence of Goiter by Tiers of Counties.

Tier *	Men %	Women %	Population (Hundreds of People per Square Mile)
1	10.3	52.7	543.7
2	9.8	33.3	3710.5
3	8.9	44.3	823.7
4	14.4	25.6	446.0
5	4.9	33.9	288.5
6	5.2	50.3	528.5
7	6.8	44.8	488.9
8	4.3	30.0	477.3
9	4.4	35.7	342.5
10	8.3	22.2	456.6
11	3.1	42.3	246.0
12	5.0	20.5	303.7
13	2.9	31.0	333.3
14	2.8	15.6	150.4
15	8.8	35.2	239.6

* Tiers number from north to south, No. 1 being the farthest north.

EXTENT OF ENLARGEMENT

Table III shows the general degree of thyroid enlargement in both men and women for a period of five years. It reveals that while nearly three-fourths of the men

have only slight enlargement, less than half of the women are included in this group. Only about one-half as many men as women having thyroid enlargement have moderate sized goiters. Approximately three times as many women as men have marked thyroid enlargement. Simple goiter in females is more frequent, more marked, and more persistent than in males. In the men, the condition tends to be slight and to disappear rather promptly with the appearance of adolescence and maturity.

TABLE III.

Degree	Men %	Women %
Slight	72.8	47.6
Moderate	25.0	46.2
Marked	2.2	6.2

From Table IV is seen that there is little difference between the incidence of goiter in the rural and urban portions of the state. The differentiation between city and country is based upon 5,000 population. This arbitrary division is not satisfactory for this purpose, because in many small towns and villages much of the food consumed in them and in their vicinity is brought in from the outside, and the effect of local iodine deficiency is not reflected by the presence of thyroid enlargement. The women, who are more susceptible to iodine deficiency than men, promptly show a smaller percentage of simple goiter where the food is shipped in.

TABLE IV.

	Men %	Women %
Urban	12.1	37.7
Rural	8.6	40.1

PREVENTION

The early Greeks treated goiter by the internal administration of the ashes of burned sea sponges. Among mediaeval physicians Roger of Salerno, who practiced about 1170, was the first to recommend treatment of the condition by the giving of the burnt residue of seaweeds and sponges. It was not until 1820 that iodine was first knowingly used by Coindet as a means of treating en-

largement of the thyroid gland. He also demonstrated that iodine was a substance in seaweed that made it valuable in the treatment of thyroid hypertrophy.

Chatin, a Frenchman, in 1850 was the first to show that small amounts of iodine would prevent endemic goiter and cretinism. Marine, after years of experimentation in using iodine prophylactically in animal experimentation, began its administration to children in the schools of Akron, Ohio. Later, both he and Kimball so clearly demonstrated the value of iodine in the prevention of simple goiter that its use has rapidly spread through the goiter regions of the Great Lakes. In Switzerland, the results with iodine were so extraordinary that its administration as a preventive has been recommended as a public health measure.

For the purpose of goiter prevention, iodine is given in chocolate wafers containing ten milligrams of an organic iodine, as iodized salt (one part of potassium iodide to 5,000 parts of salt), by adding sodium iodide to the water supply, and through foods containing iodine. A convenient method in dealing with children is to give them one chocolate wafer or tablet once a week throughout the year. The danger involved in such doses is practically nil. In exopthalmic goiter, iodine should be taken only under the direction of a physician. Even in this disease its value has been shown by Boothby, Plummer, and others.

COMMENTS

1. Simple goiter is very common among boys and girls of high school age in Illinois. Approximately 5% of the former and 25% of the latter have some hypertrophy of the thyroid gland.

2. This condition in boys tends to be slight and to disappear with the approach of adolescence and maturity. It is, however, far more frequent in males than is generally supposed.

3. Goiter is more common, more persistent, and more marked in girls than in boys.

4. In Illinois, the incidence of goiter tends to decrease from the north southward and from the east, westward.

5. In this state there seems to be some tendency for goiter prevalence and population density to show coincident rise and fall.

6. There is not much difference in the prevalence of goiter in rural and urban sections. Although the greatest population density is in the northern part of the state, the section with the highest goiter incidence, fewer women in the city than in the country have goiter. This fact, taken in connection with the decrease in thyroid enlargement in both men and women in the tier of counties containing Cook County, may be an expression of food variation, greater accessibility to sea food, and better medical attention to be found in cities.

7. In the comparison of the occurrence of goiter in men and in women in the city and in the country, it is not apparent why, in each instance, the prevalence in men should be the reverse of that in women, who are peculiarly susceptible to iodine deficiency. There may be some dietetic difference not evident. It is not uncommon for diseases due to food inadequacy to show a remarkable tendency in sex selection. For example, in Italy pellagra is about equally prevalent in men and in women; in the United States, more than twice as frequent in women as in men.

8. The regional distribution of goiter and the direct relation of the thyroid to physical and mental characteristics and its inter-relation with other glands of internal secretion may be a means by which certain districts stamp their local color upon the personality of its inhabitants.

9. The reason for more marked influence of iodine deficiency in women than in men is not clear. The fact that thyroid often shows enlargement coincident with adolescence, menstruation and pregnancy indicates a functional relationship to sex that is still not clearly defined.

10. As administration of amounts of iodine, too small to produce harmful results except in the most unusual cases, will prevent hypertrophy of the thyroid, every girl between eleven and sixteen and every pregnant woman in endemic goiter regions should be given enough iodine in chocolate wafers, as iodized salt, Lugol's solution, sodium iodide, or shipped-in food containing iodine, to protect them against goiter.

IMPRESSIONS OF ENGLISH SEWAGE DISPOSAL PRACTICE

PAUL HANSEN, OF PEARSE, GREELEY & HANSEN, ENGINEERS, CHICAGO

During the summer of 1924 the writer visited England, attended an international conference of sanitary engineers, visited a number of sewage treatment works and gained certain impressions regarding British sewage treatment practice. It is the purpose of this paper to set down some of those impressions without any attempt to go into deeply technical matters.

The conference of sanitary engineers afforded an especially good opportunity to observe habits and tendencies of thought among British engineers on the subject of sewage disposal. Practically all papers and discussions were upon some phase of the activated sludge process. Sprinkling filters were hardly mentioned and as might be supposed little attention was given to the older processes excepting as these came up incidentally. It was quite obvious that activated sludge, or as they prefer to call it, bio-aeration is the accepted process of the day, though a few engineers, and among them some of the best informed and more conservative minded, in private conversation expressed their belief that sprinkling filters are by no means obsolete.

Curiously enough, very little was said in the public discussion to justify activated sludge on the grounds of ultimate economy. The fact that installation costs are much cheaper than for any other process seemed to constitute the weighty consideration in favor of activated sludge. The unemployed situation as well as the general financial situation then prevailing may have had something to do with this attitude. It was and probably still is difficult to obtain money for installation costs, but it is relatively easy to obtain appropriations for labor for maintaining public works due to efforts to assist the unemployed.

The main cleavage of thought was over the relative merits of aeration by mechanical means such as paddles and propellers and aeration by means of diffused air. The two schools that have developed out of this con-

troversy, and it impresses one more as a controversy than a genuine seeking after truth, are quite confident of the correctness of their respective positions and are inclined to claim everything and admit nothing. It is difficult to say which method of aeration has the greater support but the school in favor of mechanical agitation is gaining many adherents.

The process of bio-aeration is still so much in the developmental stage that it was difficult to obtain convincing evidence in favor of either diffused air or mechanical aeration, and the proponents of each method in private conversation were quite free in stating what the other method could not accomplish and what they were quite sure could be accomplished by the methods advocated by them.

The proponents of diffused air claim in general that aeration by agitation takes up a great deal of space because of shallow depths required in the aerating tanks, that relatively costly construction is involved, that long aeration periods are necessary and that at least thirty horse-power hours are required to treat one million Imperial gallons of sewage. For diffused air they claim the advantage of deep tanks and hence low construction costs, simplicity of operation, more perfect control of process, low power demand not exceeding 25 horse power hours per million Imperial gallons, and a probability of cutting power demands down to 15 horse power hours through improvement in details. Typical of such possible improvements is cited the "Manchester Bottom", an arrangement of porus diffusion plates along one side of the aerating channels which produce a helicoidal motion of the sewage along the length of the channels and which results in a very definite economy of air. They also cite improvements in air compressors and are now trying out a reciprocating type, not yet perfected, which is expected to show greater efficiencies than the rotating types common in America.

The proponents of mechanical agitation claim light construction involving simple form work or merely low thin brick walls, and point out that old contact beds can readily be utilized thus saving very materially in construction costs. They also claim low power require-

ments not exceeding 25 horse power hours per million Imperial gallons, and with improved large scale works they expect to reduce the power requirements to at least 15 horse power hours. Diffused air they maintain is uneconomical, requiring 40 to 60 horse power hours per million Imperial gallons, is complicated and subject to derangements on account of leaky air pipes, clogged diffusion plates, etc.

Generally speaking, it was difficult to obtain analytical and cost data that would permit a reliable comparison of performances at different installations, though probably a more persistent effort, if time had permitted, might have resulted in obtaining a little more comparative data. The general tendency is to compare sewage on the basis of oxygen consumed using different procedures in different laboratories. This method is at best an indifferent measure of the strength of sewage and different procedures give widely varying results.

All that can be said is that both diffused aeration and mechanical aeration have merits, the visible results obtained by both methods are impressive, and they are sufficiently close together in point of economy to deserve careful consideration by the engineer who is called upon to design work.

There is also a cleavage among the proponents of mechanical agitation, one group favoring a paddle wheel type of agitation with very shallow aerating channels as developed by Haworth at Sheffield, the other group favoring a propeller type rotating on a vertical shaft at the surface of a relatively deep tank. This latter device is patented and known as the Simplex, and is manufactured by Ames and Crosta. The Sheffield system is not patented, as Haworth is strongly opposed on principle to professional engineers taking out patents on anything they may design. Haworth's view does not seem to be a view generally held by British engineers.

While the sludge disposal problem in connection with activated sludge is by no means ignored in England, it is not given anything like the emphasis given it in this country. Much has been said and is being said about the high fertilizer value of activated sludge but actually no activated sludge has been dewatered and marketed

on a commercial scale, and as in this country economical methods are only a prospect and not an accomplishment. The experiments and studies on dewatering activated sludge carried out by the Chicago Sanitary District and by the Milwaukee Sewage Commission are far more complete, thorough and on a larger scale than anything that has been done in England.

At most English plants, sewage receives more or less prolonged sedimentation either in detritus tanks or sedimentation basins and excess activated sludge is mixed with the more or less septic sludge from these devises and applied to land or drying beds. In some instances a market is developed for this material but at a very low price, while at others it is either plowed into the ground or removed and dumped.

Contrasted with American practice, British engineers are inclined to build large scale experimental plants of such permanent construction that they may become a part of the ultimate works if they prove successful. The only comparable installation in this country is the Desplaines River plant of the Chicago Sanitary District which is of permanent construction but of such flexible arrangement as to constitute in effect an experimental plant, but even this plant was preceded by very careful and extensive experiments in temporary wooden structures on a relatively small and cheap scale, yet on a scale distinctly larger than might be termed a laboratory scale and large enough to give reliable indications.

In English sewage treatment practice there is to American eyes a curious mixture of antiquated devices and bold novelties, the psychology of which is a little difficult to explain. In a number of plants sedimentation tanks and contact beds built over a quarter of a century ago, types long since abandoned in this country in the larger works, are still in regular and reasonably effective operation, while alongside are bio-aeration plants of a type that no American engineer has yet dared to build on more than a small experimental scale.

The most plausible explanation is about as follows: The prevailing habit in the older and more densely populated European countries is to build well and for permanence. There is also the habit of careful main-

tenance and upkeep observable in every detail of life. So it is with sewage treatment works; once built they are maintained and operated with most conscientious care until their lack of economy in comparison with more modern methods absolutely forces a change. Even when changes are made, preference is given to new methods which permit a maximum utilization of old structures, thereby bringing about novel arrangements, as witness the adaptation of old contact beds by Haworth at Sheffield to the activated sludge process. Furthermore, a skill in the manipulation of the older devices, especially settling basins and detritus tanks, under conditions obtaining locally causes the operators to actually prefer these devices to new arrangements.

The desire to use existing structures only partially accounts for the boldness with which novelties are installed. Perhaps the success of British operating engineers in getting results out of whatever they happen to have gives them confidence in the success of whatever they may install. Another thought is that because of low water consumption and consequent low sewage flow amounting to $\frac{1}{3}$ to $\frac{1}{2}$ of the flow usually obtained in the United States, the works after all are not great as compared with our standards, and the full size test installations which treat one-half million to a million Imperial gallons are not so very large or costly though they may constitute a relatively large proportion of the total treating capacity. Certainly England wastes far less in rash construction than we waste in unnecessary neglect and abandonment of sewage treatment works.

Another significant feature of English sewage disposal practice is the prevailing acceptance of the necessity of keeping the streams of the country clean. England has gotten well beyond the point where sewage treatment works are built and operated as a result of coersion by injured riparian owners. It is now done with the same willingness and matter-of-factness exhibited by the conscientious householder who wants his back yard as clean as his front yard. Sewage disposal departments are well ordered, well manned and stable, quite on a par with the water department or any other department operating a municipal utility.

By way of illustrating the foregoing general remarks, very brief description will be given of a few plants visited.

At Eastham, in the London District, there is an experimental bio-aeration plant having a capacity of about one-half million Imperial gallons designed along the lines of Haworth's installation at Sheffield. The sewage first receives a rough screening in the sewer, by means of a mechanically cleaned screen placed in the sewer. Sewage is pumped from the sewer into detritus tanks having a retention period of about twenty-four hours. These tanks are shown in Fig. 1, one of them being empty. These tanks are typical, though most of the more recent detritus tanks are built with hopper bottoms.

From the detritus tanks the sewage flows into the aerating channels, as shown in Fig. 2.

A current is induced in these channels by means of paddle wheels resembling somewhat the paddles of side wheel steamboats. The housings of these paddles are shown in the distance in Fig. 2. There is introduced with the sewage into these channels a proper proportion of activated sludge amounting to about 20 to 25 per cent of the volume of the sewage. The operation of this arrangement is more or less analogous to the self purification that takes place in a flowing stream. The total travel of the water is something like 3000 ft. The current is maintained by the paddle wheels and the paddles also induce a wave action which is regarded as very important in exposing new surfaces to contact with the atmosphere. The process of purification is thus maintained on an aerabic basis and is greatly accelerated by the presence of activated sludge. Fig. 3 shows the ends of some of the channels; the dark matter adhering to the walls gives a good indication of the magnitude of the wave action. At the remote end from the inlet the mixed sewage and sludge is drawn off into sedimentation tanks of the hopper type.

A glimpse of these sedimentation tanks, including the final outlet, is shown in Fig. 4.

Note that the outlet channel is lined with white enameled bricks and kept very clean. This affords a very practical means of observing the condition of the effluent.

Fig. 1.

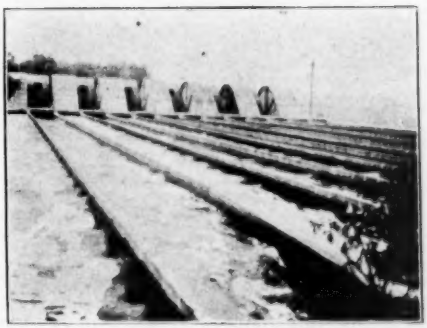


Fig. 2.

Fig. 3.

Fig. 4.

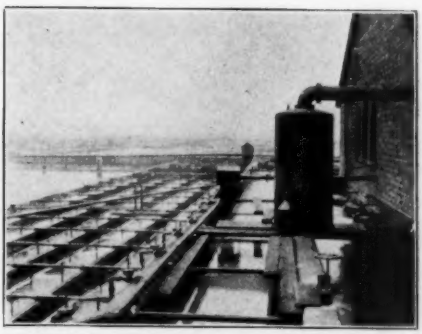


Fig. 6.

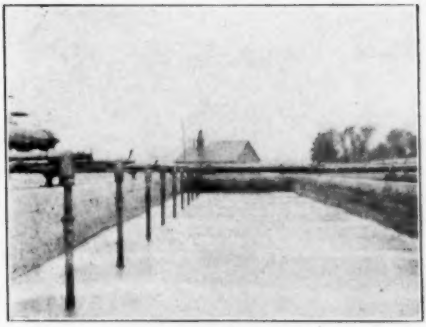


Fig. 7.

Fig. 8.

Fig. 9.

In passing, it may be noted that the treatment at the Eastham Works comprises chemical precipitation, sprinkling filters and final sedimentation tanks. The chemicals used are lime and sulphate of iron. The sprinkling filters are built of cinders and are over twenty years old. While not in the best of condition they still give reasonably good results. It is because the filters are operated beyond their capacity that new methods are now being considered. The filter effluent goes to a large final sedimentation basin and is discharged on the outflow of the tide into the Thames River. Notwithstanding the age and relative inefficiency of the older works they are still operated and maintained with scrupulous care. The grounds about are planted beautifully with flowers and shrubbery, and constitute a model of good general maintenance.

At Manchester there is still in operation the first continuous flow activated sludge plant, shown in Fig. 6.

Fig. 7 gives a good impression of the effect of the Manchester bottoms in inducing crosswise currents. The air is introduced at the bottom of the tanks on the left which causes the water to rise on the left and then travel to the opposite side of the tank on the right.

A new plant has recently been installed at the Withington Works at Manchester, which is shown in Fig. 8.

This plant is very similar to the original plant excepting that numerous transverse baffles are placed in the aerating channels with a view to inducing more effective displacement. There is but a small opening in each baffle near the bottom on the side opposite from that on which air is introduced. A glimpse of the final sedimentation basin, which receives the sewage and sludge from the aeration channels, is shown in Fig. 9.

At Reading there is an activated sludge plant of the diffusion type under construction. The notable feature of this plant is the very great depth of the aerating tanks, namely, 22 feet. Fig. 10 shows one of these aerating tanks partially completed. From the structural point of view this plant is also interesting. Gravity walls of very great thickness, namely, about 7 feet are used. The

exteriors of these walls are made of brick. The bricks are carried up a few courses at a time and serve as forms for the mass concrete within the walls. Some idea of the character of these walls can be obtained from Fig. 10.

The inside of one of the final sedimentation tanks at Reading is shown in Fig. 11. These tanks contain what is known as the "Clifford Inlet", a device which prevents the sewage from rushing to the bottom of the tank and disturbing the sludge. This inlet consists simply of a pipe discharging into a bucket, as shown in Fig. 11. Surrounding the pipe and bucket is placed a baffle arrangement which is not shown in the Figure. This baffle permits the liquid to flow gently downward to about mid-depth of the tank and then laterally upward and out over the outlet weirs.

At Birmingham there is an interesting experimental development comprising the use of bio-aeration as a preliminary treatment to sprinkling filters. It is stated that this preliminary treatment increases the population loading that can be placed on the sprinkling filters from 20,000 persons per acre to 60,000 persons per acre. The period of aeration is short, only about one hour. The volume of sludge used in contact with the sewage is also very small, not exceeding seven per cent. The theory of the process is shown graphically in Fig. 12.

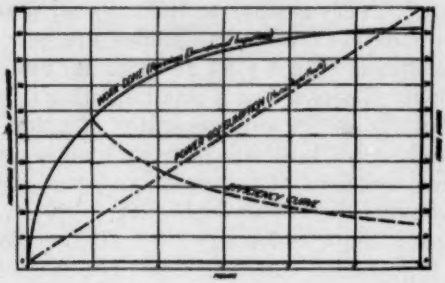


Fig. 12.

This chart shows that after one hour's operation the efficiency curve falls off rapidly. Accordingly the Engineers of the Birmingham Tame & Rea District reasoned

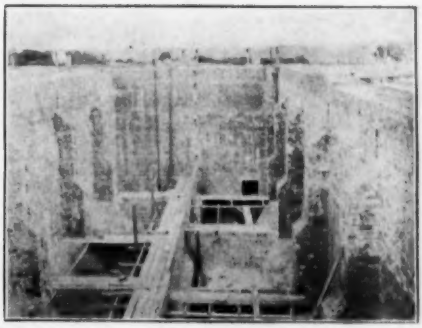


Fig. 10.

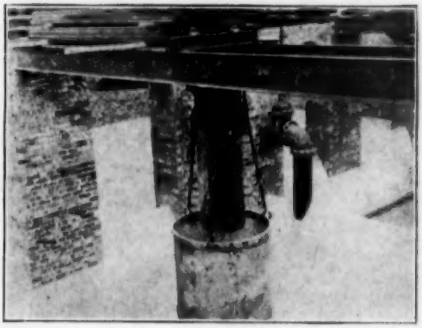


Fig. 11.

that a short period would obtain the maximum results with minimum economy. Because the process is not carried to completion the sludge is reaerated for a considerable length of time, at least six hours.

The general plan of a complete unit for a preaeration plant is shown in Fig. 13, and a longitudinal section as

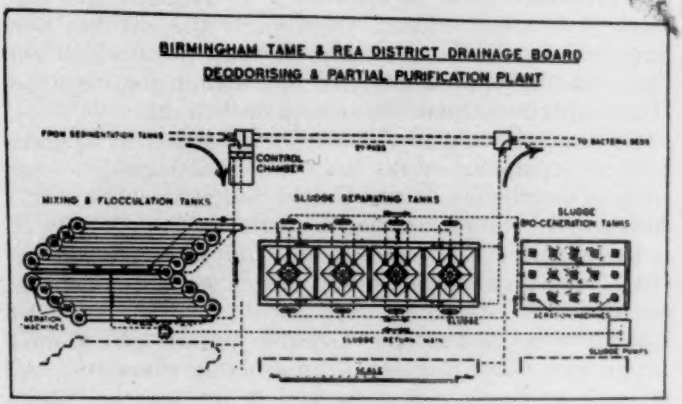


Fig. 13.

shown in Fig. 14. At the present time, only a portion of this unit has been built.

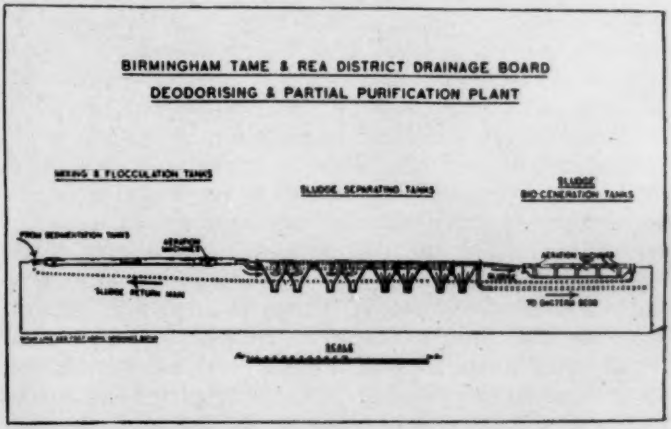


Fig. 14.

This combination of treatment, namely, preliminary treatment with activated sludge and subsequent treatment on sprinkling filters, seems to be well adapted to peculiar local conditions at Decatur, Illinois. The factor at Decatur which makes the conditions unusual is the presence of a large volume of corn products wastes which are difficult to treat on sprinkling filters and which produce pronounced odors. Accordingly the city has been induced to put in a small experimental plant which will test out the applicability of the Birmingham method. This experiment plant is now in operation.

By way of summary, it may be said that in England sewage treatment works may not be designed so well or so carefully as in the United States. On the other hand, their maintenance and operation is generally on a far superior basis than in the United States. Moreover, the general attitude toward sewage treatment works is one of settled acceptance. They are installed and operated as a matter of course and are placed upon a par with other utilities of an exacting character. All streams in England may be said to be clean and satisfactory for the use to which they may be put.

A DEMONSTRATION ON THE POLLUTION OF THE ILLINOIS RIVER

R. E. Greenfield, Illinois State Water Survey Division

The destruction by pollution of several of our Illinois streams has reached an advanced state. The loss to the State in fish life, sport, recreation, and potential water supplies, while hard to put in tangible figures, is nevertheless real.

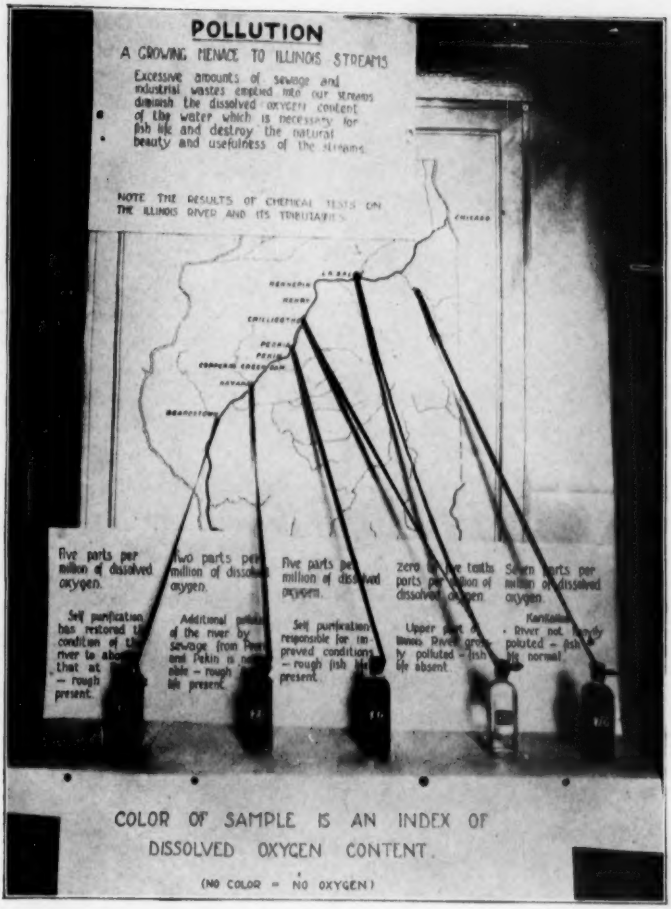
The proper evaluation of the extent of pollution of any particular stream requires considerable scientific study and the consideration of several different sorts of tests. As an illustration, however, of the sort of evidence used, the dissolved oxygen content of the Illinois River is given at several points along its course. The content of dissolved oxygen in a stream is extremely important since without oxygen none of the higher forms of aquatic life can exist. Of course, the dissolved oxygen varies in any stream from day to day as well as from hour to hour, but the results shown are figures that are typical of the results obtained in the summer months at the time of normal river stages.

It is to be seen from the illustration that the entire upper portion of the river down to Chillicothe, 140 miles from Chicago, is at times devoid, or nearly devoid, of oxygen. Due primarily to the action of the wide water of Lake Peoria, a rapid rise is usually experienced between Chillicothe and Peoria, typical figures for the Peoria section being 5 ppm. Below Peoria, the sewage of Peoria and Pekin causes some lowering to at times as low as 2 ppm. with a gradual rise again due to self-purification as we go farther south. At Beardstown figures comparable to those at Peoria are ordinarily attained.

As a comparison we may take the Kankakee River, one of the tributaries of the Illinois River which is still relatively unpolluted, where we will ordinarily find an oxygen content of 7 ppm. or over. When we consider the importance of oxygen to all higher aquatic life we must realize how far from normal is the Illinois River in all places, the entire upper portion during some seasons of the year being utterly unsuited to a normal aquatic life,

and the lower portion, while supporting some fish life, being unsuited to much of the more delicate fauna.

The illustration accompanying this is a picture of a graphic demonstration of the above facts which has been exhibited at the State Fair at Springfield and at other places in Illinois during the past year.


POLLUTION
A GROWING MENACE TO ILLINOIS STREAMS
Excessive amounts of sewage and industrial wastes emptied into our streams diminish the dissolved oxygen content of the water which is necessary for fish life and destroy the natural beauty and usefulness of the streams.
NOTE THE RESULTS OF CHEMICAL TESTS ON THE ILLINOIS RIVER AND ITS TRIBUTARIES
CHICAGO
KENNEDY
HENRY
CHILLICOTHE
PEORIA
PEKIN
HAVANA
BEARDSTOWN
Five parts per million of dissolved oxygen.
Self purification has restored the condition of the river to above that at — rough present.
Two parts per million of dissolved oxygen.
Additional pollution of the river by sewage from Peoria and Pekin is responsible — rough fish life present.
Five parts per million of dissolved oxygen.
Self purification responsible for improved conditions — rough fish life present.
zero to five tenths parts per million of dissolved oxygen
Upper part of Illinois River greatly polluted by — fish life absent.
Seven parts per million of dissolved oxygen.
Kankakee River not greatly polluted — fish life normal.
COLOR OF SAMPLE IS AN INDEX OF DISSOLVED OXYGEN CONTENT.
(NO COLOR = NO OXYGEN)

RECLAIMING APPARENTLY HOPELESS CHEST CASES

Dr. Don W. Deal, Dr. George Thomas Palmer, and Dr. Hermon H. Cole, Springfield

A generation or so ago, chronic diseases of the lung, of which pulmonary tuberculosis was the most common and the most formidable, were regarded with the utmost pessimism not only by the lay public, but by the medical profession. It was not uncommon for even the thoroughly competent physician to raise the question as to whether a case of indisputable and well established consumption ever resulted in recovery.

Within the past two decades, however, with the tremendous interest which has attached to tuberculosis in the greatest popular campaign that has ever been waged against any disease, the professional attitude has materially changed and it has come to be recognized that the tremendous fatality formerly attributed to the disease was due largely to failure to recognize it in its earlier and more readily curable stages.

Early diagnosis and modern hygienic treatment, in which rest out-measures all other factors in importance, have led to the recovery of countless thousands until, the last few years, it has become a sort of axiom that tuberculosis is a distinctly curable disease provided diagnosis is made and treatment begun during the early stages and carried out properly over a sufficient length of time. In other words, it has come to be accepted that cure of tuberculosis depends on diagnosis made early enough and complete physical rest and treatment continued long enough.

While this statement is not entirely correct,—while there are certain types of pulmonary tuberculosis which are hopeless however early the diagnosis or whatever the method of treatment—accent is still placed upon early diagnosis as the big factor in cure.

On this account, many of the scores of sanatoria which have developed during the past ten or fifteen years have confined their attention to early or moderately advanced cases, closing their doors upon those in the more advanced stages of the disease and relegating them to the ranks of the hopeless and the incurable. More than one

competent authority has been quoted to the effect that, while we have made enormous strides during the past few years, while the mortality from tuberculosis has been reduced fully fifty percent and while the earlier cases are curable, we are as helpless as we have always been when confronted with far advanced active pulmonary disease.

It is for the purpose of correcting this widely spread impression and for the purpose of painting in true colors a more promising picture for the advanced consumptive in the public mind that we present these remarks drawn largely from our practical experience in the field of thoracic surgery in the service of the Palmer Tuberculosis Sanatorium.

One of the reasons for our utter hopelessness in regard to serious diseases of the chest has been the prevailing belief among physicians and surgeons as to the extreme hazard of entering the thoracic cavity in any form of surgical procedure. This impression was largely dissipated during the World War when our experience with wounds of the chest proved to us that very extensive surgical interference may be conducted within the chest without fatal or even critical results. During the war, we learned that the exposure of considerable areas of either one or both lungs need not result in tragedy, and we found that the chest may be entered with reasonable impunity by the surgeon if entered with a full and intelligent conception of the anatomic, mechanical and physiologic conditions to be encountered.

As a result of this new knowledge, several surgeons have approached the chest more boldly and more hopefully than, in the past so that there is already some ground for the acceptance of the prophecy, that in the next decade or two, the thorax will be invaded with the same sense of security that we have experienced in entering the abdomen in the past.

As previously intimated, the most important factor in the treatment of pulmonary tuberculosis, as is true in most inflammatory conditions, is absolute and complete rest. If we are dealing with an inflammed joint proper surgical procedure indicates the complete rest of the joint, which we would probably bring about by the employment of a plaster cast. In active pulmonary tuber-

culosis, we are dealing with an inflammed or ulcerated lung but unfortunately, as is true with the heart, it is impossible to place the lung at absolute rest. For the maintenance of life, it is essential that the patient should continue to breathe. To bring about as complete rest as possible however, the modern hygienic treatment of tuberculosis requires complete rest in bed over periods of months or years together with complete mental and nervous rest attained through peaceful environment and protection of the patient from worry, anxiety or even immoderate amusement and entertainment. The object to be attained is to reduce the respirations to the smallest possible number and to make them as shallow as possible —a condition of definite localized rest. It is to attain this end, and incidentally other ends of lesser importance, that modern successful chest surgery has attained its first victories.

Regardless of the popular opinion to the contrary, the intelligent and conservative surgeon avoids operation until it becomes imperative, and in the serious and advanced diseases of the chest every other resource for obtaining rest of the lung is exhausted before surgical measures are employed.

The late Norman Bridge pointed out a great many years ago that the patient may control the frequency and the depth of respiration very largely by will, and S. Adolphus Knopf has recently worked out a clever scheme whereby the patient may voluntarily reduce his respirations from over twenty to less than ten over considerable periods of time and without inconvenience.

Webb and Gilbert have attained comparative rest of the diseased lung by causing the patient to lie constantly on the affected side with the chest wall supported by sand bags.

After numerous suggestions of partial immobilization of the chest by the application of broad strips of adhesive, there have recently been placed on the market so-called chest splints, so devised as to exert the maximum of pressure over the affected area and thereby partially limit respiratory excursion.

All of these plans are of value and prove distinctly valuable in promoting arrest in a large proportion of

cases, but fail to benefit that considerable percentage of more advanced patients who have been so unfortunately neglected in the past.

A great many years ago there was introduced an operative procedure known as artificial pneumothorax, in which the affected lung is collapsed by introducing air into the pleural space of the affected side. You will recall that the pleura of one side constitutes a complete bag, one side of which is adherent to the chest wall and the other adherent to the lung. The introduction of air into this pleural space gradually expels the air from the lung which is finally firmly collapsed. The affected lung is thus placed in what may be regarded as an air splint, the pressure of which may be regulated by the addition of air from time to time.

Aside from the relatively complete rest given to the affected lung, in this way great benefit is also attained through the fact that the air pressure squeezes out of the lung the poisonous pus and gaseous material which is responsible for the fever and other symptoms of tuberculous disease.

This operation experienced various vicissitudes and underwent periods of changing popularity, but today is accepted as a distinct part of the modern treatment of pulmonary tuberculosis. Unfortunately, artificial pneumothorax is applicable to only a certain percentage of cases. It cannot be employed when both lungs are seriously diseased and it is likewise impossible when the two layers of the pleura are adherent through previous attacks of pleurisy.

Artificial pneumothorax is the artificial production of lung collapse by easy stages extending over a period of a month or more, and is done thru a small needle introduced between the two layers of the pleura. The needle is connected by means of a rubber tubing to a machine which measures the amount of air introduced at each sitting and so fitted with a manometer that the intrapleural pressure may be measured and altered at will by the operator. As compared with the more serious operation of thorocoplasity, which aims at the same end result tho not so complete, it is to be considered a comparatively mild procedure. It is done under local anesthesia and

treatment must continue over a period of a year or two to obtain results. Its drawback lies in the fact that it is applicable to cases of unilateral disease, and its accomplishment is difficult or impossible in the presence of extensive adhesions. As would be expected, the end result of artificial pneumothorax and extra thorocoplasity are very similar, the main difference being that in the artificial pneumothorax the collapse is more complete and there is no outward sign of its having been done. It has the advantage that it may be undone at any time by the operator and has the possibility always at hand of giving back to the patient a completely healed and functioning lung.

Extra pleural paravertebral thorocoplasity is the outgrowth of years of experience in operations upon the chest wall, and while the main credit has been given to Sauerbruch for the present technique used and herein briefly described, there is no question that a host of other men contributed by other operations of similar nature to the present form. It is done under gas oxygen anesthesia on patients who are suitable for pneumothorax but where intrapleural adhesions prevent its use. Sections of rib are removed thru means of a posterior incision from the first to the twelfth rib from the spine to the angle of the rib, thus allowing the whole chest wall deprived of its bony frame-work to fall downward and inward. The collapse is produced by the lung and chest wall collapsed together, and when complete is a fixed and permanent condition. It is usually done at present in two stages, the lower half first in order to lessen the danger of an aspiration pneumonia. In our series of extra-pleural thorocoplasity we have had so far but one fatality. This patient died some months after operation from a complicating heart condition with which the operation had nothing to do. The tuberculous disease in this patient was successfully arrested. The others operated as far back as two and three years ago have all showed excellent results tho some of them of course have not and will not regain complete physical efficiency. It is to be noted that in practically all, the disease activity and grave intoxication has been entirely arrested and we are highly satisfied with the results so far obtained. We believe

that this operation has a much broader field of usefulness than is now generally conceded and are using it in modified form for the control of chronic empyema, of which I shall have more to say later.

One of the arguments against major operative work *within* the chest has been the very high mortality. So far our experience has not confirmed this prohibitive death rate. Even tho the mortality here is high, however, as stated by other observers, even tho twenty-five to fifty percent of patients succumb, it must be borne in mind that the majority of these patients have exhausted all the other means of treatment and that death is inevitable without some form of radical interference. In other words, saving of life in these patients is to be regarded as a net gain. In intrapleural work exclusive of pneumothorax the field is quite limited, but we have determined by actual accomplishment that very extensive work may be done upon the lung itself provided means are employed to combat the sudden changes of pressure to which the great mortality is due. This has been done by inducing a preliminary artificial pneumothorax and then proceeding to operate as in any other part of the body. One case will serve to show what may be done. A patient suffering from gunshot wound of the chest received preliminary treatment by artificial pneumothorax. The chest was then opened widely and the bullet removed as tho working in an abdomen. No shock or other disturbance was noted. In another patient the whole lobe of the lung was removed after preliminary artificial pneumothorax for bronchiectasis and with absolutely no disturbance. Our experience in this field has shown us that the principle upon which these operations must be done is that of preventing sudden changes of intrathoracic pressure, and very extensive operations may be done in comparative safety by the simple means of the preliminary establishment of operative intrapleural pressure conditions.

Our experience has shown us definitely that men may live and work with one lung completely lost and that certain limited activities are open to him with one-third his original amount of lung capacity. We believe that this method of operating intrapleural conditions offers con-

siderable promise for the eliminating or control of tumors, foreign bodies, etc., which occur at times in the pleural cavities and which are now considered nonoperable and hence fatal. It is the combined opinion of Doctors Palmer, Cole, and myself that a stage has been reached in the progress of thoracic surgery in which it may be stated emphatically that no patient suffering from advanced tuberculosis, bronchiestasis, chronic empyema, or foreign bodies within the lung or pleura should be relegated to the ranks of the incurable until he has been thoroughly studied with the view of the possibilities which this type of surgery may have to offer him. A fair percentage of any or all of these conditions are operable and should receive the benefit at least of study with such a move in view.

In conclusion I should like to state (1) that mechanical treatment of many chest conditions heretofore regarded as impossible is now a well established fact. (2) Extensive work may be done within the pleural cavities, even directly on the lung, by the preliminary use of artificial pneumothorax. (3) Operations upon the chest wall for the control of disease within the lung has made great strides recently and offers considerable promise for the future. (4) Every patient suffering from serious intrathoracic disease should be considered in the light of surgery. A fair percentage of these patients are entirely curable and a much larger percentage can be definitely improved.

INERTIA UTERI (IN A CASE OF UTERUS BICORNIS) DUE TO ENTIRE ABSENCE OF MYOMETRIUM BELOW THE FUNDUS

Dr. Milton DeWitt Pollock, Decatur

The patient was referred to me by Dr. V. F. Keller, of Decatur, Illinois, for surgical intervention, stating that her period of gestation had apparently run ten and a half months or more; that he was unable to induce labor by the usual methods, and while he could not account for the inertia, there was something very unusual about the behavior of the case, and he felt that surgery was indicated. She was admitted to St. Mary's Hospital, February 5, 1923, feeling well and with no signs of impending labor.

A BRIEF HISTORY OF THE CASE

Mrs. B. J. P., a primipara, American, age seventeen years, stout build, weight 130 pounds, height 5 feet, 2 inches. Always healthy except for some of the children's diseases. Menses began at the age of thirteen, fairly regular and normal in amount, lasting three or four days, with but little distress; married two years, never pregnant before.

She is one of six children, four sisters and one brother. One sister died in infancy, cause unknown. Another sister died at two years of some fever; two sisters and a brother living and healthy. Both parents are living and in good health.

Patient's last menses occurred March 6, 1923, eleven months and eleven days prior to delivery. She soon began complaining of nausea, especially in the mornings and after her meals. The nausea continued throughout gestation but not pronounced. No history of severe abdominal pain, or pain with palor or fainting, or shock. No uterine hemorrhage or passing of uterine decidua. No history of extreme peritoneal tenderness or invalidism. The fetal movements were moderately painful but no pronounced abdominal distress. She felt first movement August 15, 1923, six months before delivery; so we are justified in concluding that gestation had run ten and a half months and probably longer.

Physical examination briefly was as follows:

Patient's temp. 98. Pulse 90. Resp. 18.

Urine negative. Wassoman negative. Pelvic measurements quite normal. Conjugate 11 cm. Transverse 12 cm. Oblique 12 cm.

On inspection of the abdomen, the fetus lay high, well up to the costal arch, and its outlines were so plain that one was justified in making a diagnosis at once of a transverse position by inspection alone. The least movement of the child was also readily seen.

On palpation I was impressed immediately with the thinness of the abdominal wall, and the ease with which the child could be outlined and its every movement felt. Lying in a U-shaped position, its occiput rested over the left iliac crest and its sacrum over the right iliac crest, floating high apparently in the abdominal cavity. The head could be pushed down toward the pelvis, the breech in turn rotating up under the right costal arch; on the other hand, the breech could be depressed downward, the head in turn rising up under the left costal arch, but it was very difficult to depress the head down sufficiently to engage the superior strait, and when so depressed, it would not remain, but soon would rise in the abdomen and assume the transverse position again.

Bimanual examination was unsatisfactory, because of the difficulty in reaching or palpating the lower segment of the uterus through the vagina. Even with counter pressure from above it was only possible to touch the uterus with the tip of the examining finger. I was not able at this time to even locate the cervix, which I attributed to the probability of its being rotated well back out of reach, and to the presumption that the cervix would also be very thin and therefore difficult to palpate or locate.

In considering the possibility of abdominal pregnancy I was unable to outline an empty uterus alongside of the tumor mass, either by palpation or through the speculum. The latter proved just as unsatisfactory also in locating the cervix.

The X-ray taken at the time did not throw much light on the differential diagnosis or the cause of the inertia.

It does demonstrate, I think, over-development of osseous tissue for a full term fetus and goes to substantiate the other evidence of excessive length of gestation. This picture does not represent the true and persistent position of the fetus. In order to demonstrate whether or not the head would engage the superior strait I rotated the head downward and forced it down into the pelvis as far as was possible just prior to taking the picture. I should have had one taken while in the transverse position also for comparison.

While physical examination pointed to abdominal pregnancy in many respects there were too many negative signs, and the previous symptomology of the patient was also negative. So we decided that it was probably a case of intra-uterine pregnancy with inertia of unknown cause up to the present time. We felt, however, that surgical intervention would eventually be the only solution, and therefore refrained from resorting to mechanical methods of inducing labor because of its danger of increasing the possibility of subsequent infection.

The patient was put on one minim of pituitrin every three hours and watched closely for first sign of beginning uterine contraction; this was continued for five days up to February 10th, when the dose was increased to two minims, and later three minims, with negative results so far as uterine contraction was concerned. The patient at this time began to complain of being uncomfortable, and nervous, with a pulse rate of 100, thready and slightly irregular, which was attributed to the pituitrin, so we discontinued it, and decided to operate the next day.

February 17th, the patient having been previously prepared in the usual way, a median incision was made through the lower abdomen. On opening the peritoneum what resembled very much both in color and consistency the ammotic sack, welled up through the incision, and both assistant and I exclaimed, "abdominal pregnancy". On separating the abdominal walls farther, the outline of the child was very apparent, as the thin walls of the sack folded down over it. On sweeping my hand around the border of the sack, I found no adhesions or placental attachment, and passing up over the superior pole and pulling it down into view, I discovered that we were deal-

PLATE I.

ing with a bifurcated uterus, or an exaggerated uterus arcutus, in which the myometrium was confined to the fundus, which represented not more than the upper third of the uterus or sack. The lower two-thirds, which contained the fetus, consisted of a mere fibro-elastic bag, absolutely void of myometrium, and proved on opening to be approximately two millimeters thick, and extremely poorly supplied with blood vessels, hemorrhage being almost nil from the cut edges.

I delivered a six pound normal female babe, which cried out as soon as extracted, in protest of the long imprisonment. Its fontinels were small and ossification in general gave evidence of over-development for a normal term babe. The placenta was attached to the fundus of the left horn and was quite adherent. It was necessary to completely invert this horn out through the uterine incision in order to detach it. The sack was closed with two continuous chromic sutures, drawing the peritoneum over a plain catgut lambert suture. The abdomen was closed in the usual way. Mother and child's convalescence was uneventful except for a superficial abcess in the lower angle of the abdominal incision. They remained in the hospital twenty-eight days.

I examined this patient again on January 21, 1925, almost two years after the operation in order to ascertain the present condition of the uterus, to what extent the fibrous sack had contracted or involuted, etc. I found it to be six inches deep, as you can approximately estimate in this X-ray picture. See Plate 1. The two bent applicators, one in either horn, demonstrate the bifurcation very nicely. As I pulled them down into the lower segment with the points still separated, it demonstrated conclusively that the fibrous portion still remained saculated and had never completely involuted after two years' time. I was also able to demonstrate this to my own satisfaction by sweeping a bent sound around in the uterus. I attempted to show the extent of the uterine cavity by filling it with potassium iodide and having it X-rayed, but this was not successful. Either we failed to distend it properly, or the tissues were too thick and dense.

In my examination at this time, I discovered the reason for not being able to locate the cervix at the former examination when the patient entered the hospital, by demonstrating a double vagina, the left side giving every appearance of a virgin vagina, small with the septum clinging close to this side. In this left vagina the cervix was located. The right side was quite patulous and no doubt was the vagina in use. This right vagina had no communication with the cervix except for a small oval opening or rent in the septum. In our preliminary examination we evidently entered the right orifice, and naturally could not locate the cervix unless the examining finger accidentally slipped through the slit in the septum.

In summing up, time will permit only a brief reference to some of the interesting features of this case.

1. Its frequency—While I have not made an exhaustive survey of the literature bearing on the case, I have made sufficient research to justify the conclusion that so extensive absence of myometrium in a uterus is in itself rare.

2. When co-existent with uterus bicornis, a single cervix and double vagina, complicated by pregnancy, certainly makes it unique in the annals of abstetrics.

3. The cause of such an anomaly—Practically all malformations of the uterus are explained by the lack of fusion of the Mullerian ducts at some point or other. The uterus and vagina are formed by the fusion of these two ducts, which are generated from the uriogenital fold, as is the kidney and ovary, the union taking place from below upward. Lack of fusion at any point throughout the length of the two canals explains almost all the malformations found, and rudimentary development of one of the ducts will account for most of the balance. The absence of the myometrium in this case was due no doubt to some defect in the early development of the Mullerian ducts, which I will not attempt to explain.

4. Accurate preoperative diagnosis in a case of this character, it seems to me, is out of the question.

5. The best method of handling it, and the only method in my judgment, worthy of consideration, is Cesarean section.

THE RESULTS OF THE APPLICATION OF SCIENCE IN THE FIELD OF MEDICINE

Dr. T. Arthur Johnson, Rockford

The progress of modern medicine, in the broad sense of this term, means much to all of us, whether we are sick or well. Our happiness and well being may be greatly affected by public health measures and may be affected considerably by what aid can be given to friends and relatives in times of serious illness and injury. The fact that business men are willing to erect and equip large hospitals to facilitate the application of modern methods to those in need of care is ample demonstration of this general interest. This is being done throughout the world without any thought of financial return.

Scientific medicine has advanced more in the last fifty years than the arts of communication, navigation and transportation. The discoveries have been as marvelous as the development of the submarine, the aeroplane and the radio. We are amazed at these wonderful achievements of modern engineering skill, but what is more marvelous than the fifteen years of added life given to the civilized world by the application of the discoveries in modern medicine, surgery and their allied sciences?

The average length of human life in the sixteenth century was between 18 and 20 years. At the beginning of the last century it was still under 25 years. The average span of human life in this country in 1870 was 41 years. At the beginning of the present century it had advanced to forty-eight years, and today it varies considerably in different countries from about twenty-four in India, to fifty-six in the United States, and sixty in New Zealand. The death rate in the United States has been reduced from 20 per thousand of population in 1880 to about 11 per thousand in 1921. This represents a saving of 500,000 lives in one year alone.

If the knowledge of preventive medicine we now possess could be efficiently applied, the average length of man's life could be extended at least ten years, and his industrial efficiency increased in proportion. Iusurance companies anticipate an average life expectancy of 75 years in the near future.

In the present seemingly satisfactory state of our public health, few of us realize what has happened to such once devastating diseases as typhoid fever, smallpox and diphtheria.

Typhoid fever was until recently a very common and dreaded disease. In the Spanish war, more American soldiers died of this disease than were killed in battle. In the recent World War, modern preventive measures made typhoid epidemics impossible. Through the discovery of its cause, and methods of transmission from one individual to another, it has become a preventable disease, and the application of this knowledge is rapidly making this once prevalent disease a rare one.

Yellow fever once ranked with cholera and bubonic plague as one of the most fatal scourges of the human race. The last great epidemic in this country occurred in 1878. It spread from New Orleans as far north as Missouri, embracing 132 towns in eight states. Seventy-four thousand people were infected, of whom over fifteen thousand died. The discovery by Doctor Reed that Yellow Fever was carried from one person to another by a certain specie of mosquito paved the way to banish this disease from this continent. Armed with this knowledge, Dr. Gorgas made it possible to complete the Panama Canal where the French company had failed. This was done at a saving of seventy thousand lives and eighty million dollars.

In the 18th century, smallpox occurred as commonly as measles does today. Forty-five thousand people died in England, 40,000 in Prussia and 150,000 in France, while it was estimated that the total number of deaths due to this highly fatal disease was over 600,000 each year. In London at that time it was the cause of about one-twelfth of all deaths.

Before the days of vaccination, smallpox was essentially a disease of childhood because practically all were susceptible to it. Nearly everyone had his attack early in life, as children have measles in our day. Only about 6% of the children were immune and therefore escaped its ravages. Smallpox not only destroyed life and disfigured its victims, but it was at one time the most common cause of blindness in London.

Thorough vaccination is a complete safeguard against this disease as is definitely proven by the perfect control of it in countries where vaccination laws are properly enforced. In Prussia where compulsory vaccination has long been in force, it has reduced the death rate of smallpox from 4000 per million of population to less than 2 per million. In Sweden where vaccination has been thoroughly and adequately applied for over one hundred years, the death rate has been decreased from 2,049 per million of population to one per million.

Contrast this with the present smallpox situation of our own country and state where vaccination laws are lax and poorly enforced. There have been reported during the five year period from 1918 to 1924 in the United States nearly 300,000 cases of smallpox. During the same period nearly 25,000 cases were reported in Illinois. In Massachusetts where a compulsory vaccination law is well enforced and free vaccine virus is distributed to its people only 114 cases of smallpox were reported in the same five year period.

In 1923 there were over 30,000 cases reported in the United States, over 31,000 in Russia as against 195 in France and 17 in Germany. We see therefore that where scientific knowledge is applied this great scourge of mankind is completely checked. But when we relax our vigilance and the various cults and anti-vaccination propogandists tend to break down the main barriers set up against disease we must expect exactly the situation that has developed here in the last few years. Smallpox epidemics are a disgrace to any country and are due to carelessness on the part of many people and ignorance on the part of others. Many of the propogandists fall under the latter class, but most of them belong to the various healing cults and are therefore prejudiced rather than ignorant.

Diphtheria, not long ago one of the most dreaded diseases of childhood, has been rendered almost innocuous by the discovery of the anti-toxin treatment. Many of you can recall how whole families of children were wiped out in a single epidemic. If this disease is recognized on the first day and proper treatment given no one need die from it. By applying the Schick test and giving

the toxin anti-toxin mixture to those found positive, the disease may be completely prevented.

Doctors Dick and Dick, working at the McCormick Institute for infectious diseases, have discovered the cause of scarlet fever and a specific curative serum which bids fair to do for this disease what anti-toxin has done for diphtheria. The triumphs of insulin, radium, the X-ray, aseptic surgery and numerous other scientific agents need only to be mentioned to be appreciated.

While tremendous strides in the progress of medicine have been made in the discovery of the cause of disease, the diagnosis, and the methods of treatment, surgical and medical, as applied to the individual patient by the physician, far more has been accomplished in preventing disease by the wide spread application of preventive measures to the public as a whole.

The number of human ailments is so large, the physical, chemical and biological processes of the body so complicated, and the avenues of infection and the influences causing disease so numerous, that a continuous process of education is essential to keep the coming generations supplied with the thorough knowledge necessary to conquer disease.

In many sections of our country, especially in the regions of the Great Lakes, goitre is very prevalent. In dogs it has been shown that 95% of these animals living in this region show more or less goitreous changes in their thyroid glands. A great majority of goitres are due to the lack of iodine in the water supply. In some cities where iodine has been given to the school children, goitres have been found to disappear almost as if by magic. Preventive medicine has gone farther and is now preventing goitre by giving iodine to the mother before the child is born. The prevention of goitre is more important than operating for it after it has developed and possibly done irreparable damage to the patient.

The idea of periodic health examinations is another step in advance. An increasing number of people are going to their physician for examination with only slight symptoms or none at all. In this way the diagnosis of serious and insidious ailments are discovered early and

the proper advice and treatment given before destructive lesions have developed and at a time when serious trouble can be prevented. This application of the doctor's scientific knowledge to the early recognition of human ailments in their incipient stage will do more to increase the efficiency and span of man's life than the older methods of trying to cure disease when it has become thoroughly established.

PAPERS ON PSYCHOLOGY AND EDUCATION

WHAT CAN THE SCHOOLS DO IN THE RECOGNITION AND TREATMENT OF INCIPIENT MENTAL DISORDERS AND CRIMINAL TENDENCIES DURING SCHOOL AGE?

HERMAN M. ADLER, M. D., DIRECTOR, THE ILLINOIS INSTITUTE FOR JUVENILE RESEARCH, CRIMINOLOGIST OF THE STATE OF ILLINOIS

There are two methods of learning: one is by imitation, the other by experience. All human beings come into this world with a greater or less ability for acquiring learning in these two ways. Educational methods and systems have been developed in order to systematize and expedite the learning of children so as to put them into the possession of the necessary information and abilities in as short a time as possible. Teaching aims to convey by precept and example, as well as by the direct imparting of knowledge, habits which will not only fit the child to take its place in the community, but also will make unnecessary the rediscovery of the knowledge which previous generations have accumulated. This body of knowledge, of raw facts, the results of the experience and of the originality of those who have gone before, has become so large as to overshadow other aspects of the general problem of education. The teaching profession is well aware of this and is constantly seeking opportunities for increasing the scope of the curriculum to include other things than mere acquisition of facts. Nevertheless, this is a slow process and educators everywhere have been forced to compromise somewhat. Consequently the schools are almost entirely concerned now with the imparting of knowledge. The school time is so short relatively, the numbers of children to be cared for are so great, and there is so much information to be given, that there is danger of an increasing emphasis on this side, at the expense of the training and use of individual abilities.

It is fortunate for the world that the large majority of children adapt themselves well to the present curriculum. A child who has the intelligence to profit by schooling in most cases has the other functions suf-

ficiently well developed to enable him to acquire habits of perseverance, of inhibition, of self-control, and of integrity. The experience with intelligence tests, for instance, has justified the assumption that in the great majority of children the tests are a fair sample of their general development. It may be assumed, unless there is evidence to the contrary, that the degree of development observed in the intelligence will reasonably represent the amount of ability in other fields which have not been sampled.

It is because this is true of so many children that the occasional exceptional child is frequently overlooked. The child who varies from the larger group, either in the direction of superiority or of inferiority, may present a different problem. In such cases it is not safe to generalize on the results of sampling. Failure to make suitable progress at school may be due to mental defect which can be determined. Frequently, however, it is due to other causes. In the same way superior achievement at school does not necessarily indicate superiority in other fields, and therefore does not justify the conclusion that this particular child is going to be unusually successful in the world. Only recently a startling crime has attracted the attention of the world to this type of problem. The results of intelligence tests in penitentiaries and reformatories further corroborate this idea. Among our delinquents and criminals we find the same average of intelligence which exists in the community at large. The institutions have the same share of superior and inferior individuals, proportionately, as the general population.

It is clear, then, that the degree of intelligence is not the decisive factor in determining the social success of an individual. The Institute for Juvenile Research, which developed originally in connection with the study of delinquency, has been forced to extend its horizon to include problems of personality and mentality which are outside the stricter range of delinquency. The need for this type of work has been strikingly illustrated during the past two years in a study which the Institute has been conducting at the LaSalle-Peru Township High School at LaSalle, Illinois. Mr. McCormack, the prin-

cipal of the high school, has established what he has most aptly called the "Bureau of Educational Counsel", and has engaged a full-time psychiatric social worker to take charge of it. The function of the "Bureau" is to give help and advice to all the pupils of the school who have mental or personality difficulties of any sort, but particularly to those children who are possessed of adequate intelligence for the grade in which they are placed, but who are not keeping up with their classes. The psychiatric social worker investigates these cases, confers with the pupil, the teacher, the parents, investigates the social history of the child, and any other factors which might operate in causing the difficulty. All cases which the psychiatric social worker feels need special attention are referred to the psychiatrists and psychologists who go down to LaSalle from the Institute about once a month. As a result of this experience it appears that in a group of so-called normal, healthy children with sufficient intelligence to go through high school, there are numerous problems which are of serious significance to the future success and happiness of the child, which would entirely escape attention under the ordinary school routine.

Many types of problems have been dealt with. The most usual one, of course, is that of the child who is not properly placed in school, who either has not sufficient intelligence to do the grade of work which is expected of him and is therefore unhappy, or that of the child who has more than sufficient intelligence and should by rights be in a more advanced class, and is therefore bored by the work he is forced to do. These problems are relatively easy to adjust. The more difficult ones are those in which the child to all appearances is correctly placed in school and has adequate intelligence for his grade, but for some obscure reason is not well adjusted and is not keeping up with his class. Various reasons for these difficulties have been discovered, such as discrepancies in the home, social discrepancies produced by race, nationality, economic inequalities, physical defects, and so on. In many cases it has been possible to remove these discrepancies so that the child was enabled to do his school work satisfactorily and became better adjusted to his surroundings.

The problem to be faced by the psychiatrist is one of the adaptation of the individual to his environment, especially his social circumstances and conditions, with the object of obtaining the maximum efficiency and securing the highest possible rewards for the individual.

Theoretically, therefore, it is not enough for the educational system to determine the capacity of an individual and to provide him with the accumulated wisdom of our generation to the extent of his capacity. A further obligation rests upon the educational system, namely, that of determining the ability of the child to utilize both the acquired knowledge and his innate capacity to the fullest extent, through the use of such special powers as he may have, and by avoiding such weaknesses as he possesses. In consideration of this duty, the emotional life of the individual becomes of great importance. Tastes and desires, as well as repugnances and fears, are of great importance. One of the most difficult things for anyone, and especially for the young, is to determine what they really want, what they may want not only at the moment, but in the future. Even when they think they know what they want, will they be happy when it is secured? Many a person has been successful in all outward ways, but has carried with him a burden of disappointment or of frustration because of the thwarting of some youthful desire. This may be the case even where the satisfying of the original desire might not have meant success. The mere fact of having been thwarted may prove a difficulty.

In general it may be said that people are most contented when they are doing something which they can do very well. As a rule one likes to do what one can do well provided the doing of it is accompanied by recognition from one's fellow men. Most people are not strong enough to work against this. This is the outstanding characteristic, for instance, of criminals, who may be carrying out their particular criminal activities with a high degree of skill, and who may even have the respect and admiration of other criminals, but who nevertheless are oppressed by the fact that public opinion is against them and that their successes are illegal.

Professor Thomas has summed this up under four heads, which he calls the fundamental wishes of mankind: (1) the desire for security; (2) the desire for response; (3) the desire for variety of experience; and (4) the desire for recognition. Under the desire for response he groups among others some of the sex reactions, the response that the lover gets from the opposite sex, a personal and intimate response on the part of the immediate family or friends to his own personality. Under the desire for recognition he groups the general desires for applause and approval of the group in the larger sense, the public or the community.

In the actual application of mental science to this general problem the principal effort is directed towards the individual himself. The environmental factors, the social factors, can on the whole be taken for granted for the purposes of this special work. Changes and improvements to be effected, especially in the social environment, which is a problem affecting the sociologists, the educators and public officials, particularly the legislators, may be based upon the experience with the individual problems. For the purposes of this communication these larger aspects of the problem may be disregarded.

The first consideration in approaching a particular child is to determine his inherent capacity both intellectual and physical. This is well recognized now and is being carried out in most larger school systems in varying degrees. In evaluating inherent capacity, however, the determination of the actual functioning of the child as a whole is usually either entirely omitted or given but slight attention. It is not enough to know what the intelligence quotient is, whether a child is properly graded, what his ability is in various school subjects, or whether his body is reasonably well developed, but it is also important to know to what extent he can use his innate capacity, how his emotional control functions, whether he has difficulty in inhibiting dangerous impulses, what power of perseverance he has.

Here again the great majority of children present no great problem because of the fact that they are

average and therefore their individual variations will still be within the limits of normality, and experience will tend to correct whatever slight irregularities there may be. It is with the exceptional child, the one who varies from the general rule, that special evaluations may be of importance. Here, of course, as one of the most frequent causes for variation, the consideration of pathology is of importance. There is a normal variation which is expressed in a normal curve of distribution according to which some individuals are found to vary from the average for the group, where the sampling still is a fair expression of the entire organism. For instance, in regard to intelligence there are undoubtedly individuals who are superior or inferior when compared with the larger group. In the case of the low grades it is safe to assume that they are more or less evenly of low grade, that they will be more suggestible than others, more likely to surrender to difficulties, to be led by temptation, less likely to make an important contribution to the community life. But there are others in this group in whom the sampling of intelligence will not be a fair expression of the organism as a whole. In these cases one may find unexpected strength in other fields, perhaps a greater resistance against temptation, a greater conformity to the standards of the community, greater perseverance in the face of difficulties, more generosity or loyalty than one would expect on the basis of the intelligence level alone. The distribution of pathological variation is not correlated with the intelligence distribution, so that it may turn out that individuals who stand high in the scale of intelligence may also stand high in the scale of pathology. These are twisted, deformed personalities, in whom the intelligence is not an asset but a liability, who because of compelling desires or emotional weaknesses actually use their intelligence to further dangerous tendencies.

In order to meet this problem, the second step in the investigation consists in a search for discrepancies either within the child's organism or in the environment, or in the relation between the two. The search for these discrepancies should result in identification of all the major variations from the general standard of the com-

munity in which the child lives. Thus, for instance, a negro child in a white community, or a white child in a negro community, and all the other problems of race heterogeniety are to be listed as discrepancies. Again, a home should consist of natural parents, of the standard degree of security, including sufficient food, opportunities for recreation, for social intercourse, affection and home control and discipline, and all the other items which are regarded as necessary. A home in which one or several of these factors are not present, or not in sufficient degree to satisfy the ordinary standards, presents a discrepancy. The actual discrepancies are just as varied as human life, but the standard is always there.

A human being, healthy in body and mind, will ordinarily react to discrepancies by some effort at compensation. But if the discrepancy is too great on the one hand, or if the individual is too weak on the other, in any respect affecting the particular trouble, the attempt at compensation or adjustment will be more or less unsatisfactory and behavior disorders will inevitably result. A very strong person will react to even very severe discrepancies or obstacles in the environment with success. If the unfavorable condition is severe it ultimately results in increased strength by the acquired habits of overcoming it. This has been demonstrated over and over again in the lives of eminent people.

This has a very important bearing on the problem of habit training. In habit training we attempt to establish automatic responses in the child which will enable him to meet a difficult situation and solve it successfully. In carrying out such training the relative strength or weakness is of course of essential importance. A task which may be difficult for one may be easy for another. But the general conclusion remains that having learned by graduated steps to meet difficulties either by exerting more endeavor or by self control or inhibition, the habit gradually becomes established and ultimately will enable the child to meet successfully obstacles which without such training would have proved disastrous.

In the opinion of those who have worked in this field the school offers at present perhaps the best opportunity for considering such discrepancies, for evaluating

them, and for supplying the remedies. It is obviously not sufficient merely to sort and classify the children in this regard. This is the first step, but it is almost useless unless the schools are prepared to offer a remedy by training for such problems as may be discovered. In character training and habit training the emphasis for generations has been laid upon exhortation. But exhortation is not the only method, nor is it perhaps the best. The athletic trainers, the music and art teachers, in fact probably all educators, rely but little upon exhortation in their training methods. Another fallacy, it appears, has been the one that relegates character training to the home. It is assumed that the parents are, for some mysterious reason, just because they brought the child into the world, the proper agents for character training. This again is probably due to the fact that in the great majority of children a great deal can be taken for granted and the results have been good, not because the parents have been effective in training the children but because the children have been sufficiently equipped by nature with the means of acquiring protective habits. It is in the exceptions to the general rule that the fallacy becomes apparent. For instance, the principal discrepancy in a child's life may be that he has a dishonest or psychopathic parent. This is the very child that needs the greatest help. He cannot get it from his parents, nor is the school prepared to supply the lack. It must be obvious at once that the schools cannot be made responsible for all of it, but just as is observable now in connection with other branches of learning, there is an extension into the pre-school age, educational influences are making themselves felt more and more in the earlier years and it is proper to assume that if the schools emphasize habit training and character formation as part of their program an extension of this influence into the pre-school period will be an easy development.

In the actual treatment of an individual problem the remedies are briefly:

(1) The removal of such discrepancies as can be removed, either by treatment of the individual or by changes in the social environment. On the individual's

side this means a careful evaluation of the physical and mental factors, relieving any physical defects if possible, strengthening the weak places mentally, adjusting the teaching so far as possible to his particular need. Much has been done by the schools in this direction. On the environmental side and the social side it means closer contact between the school authorities and the family. It means education of the family as to its proper attitude toward the child, home discipline, recreation, health and hygiene.

(2) Strengthening by suitable practice of inhibitions, self-control, ambition, aesthetic tastes, and so forth, in the child himself. A great many of our social difficulties are due to habits of taste for vulgar pleasures, for vulgar associates, for dangerous excitement, and so on. The movement now going on in this state toward the increase of aesthetic appreciation might well be extended to the social side.

(3) Providing suitable outlets through constructive activities for such special abilities, even though relatively minor in degree, as the child may possess. This is in line with the idea that one likes to do what one can do well.

In all this training there is one principle that should be uppermost, namely, that it cannot be autocratically imposed on the child, whether it is a matter of home conditions, occupation, vocational training, or of taste. The object should be to accept the child as he is so far as possible, and to find for him the greatest expression of his personality in the direction of strength and security, to give him opportunities and outlets for his impulses as well as to surround him with proper stimulation in those directions. Public opinion is not enough to secure this. Public opinion merely sets the standard. Achievement of success depends on individual factors. It is fortunate of course that intensive individual work is unnecessary with the large majority. It is essential, however, with the minority who vary from the average. The success of the undertaking at the LaSalle High School is an indication of what can be accomplished.

Recommendations are now before the legislature which have as their object provisions for extending this type of service to all communities in the state, so as to enable the children of the state to obtain the greatest possible benefit from those abilities with which they are endowed.

FOREIGN LANGUAGE AS AN ENTRANCE REQUIREMENT AT NORTHWESTERN UNIVERSITY COLLEGE OF LIBERAL ARTS*

R. A. KENT, NORTHWESTERN UNIVERSITY

Problem:

What is the effect of the present entrance requirement in foreign language in Northwestern University upon

A. The selection of students, and

B. Student achievement?

Method:

The method used is descriptive for the most part.

Data:

The data presented are grouped under the following headings:

I. Applicants Denied Admission.

II. Persons Admitted on Condition.

III. Comparative Entrance Requirements of Other Higher Educational Institutions.

IV. General Scholastic Ability and Foreign Language Study.

V. Summary.

I—APPLICANTS DENIED ADMISSION

1. Why 97 applicants were denied admission as Freshmen in the College of Liberal Arts, Northwestern University in Sept., 1924.

TABLE I.

Causes for Refusal.

	Lang.	Math.	Units	Scholarship	Combination	Total
Men	59	5	0	4	3	71
Women	10	6	6	0	4	26
	69	11	6	4	7	97

Of the 69 who were deficient in language, 37 were in the fourth quarter of their high school classes.

*Acknowledgement is here made for assistance given by the following persons in preparing this material: The Personnel Office through E. L. Clark; J. Harold Goldthorpe, Registrar; Herbert F. Sorensen, Statistician to the Studies of the Schools; Frances Doane and Anna Markt, two of my students.

TABLE II.

Placement of the 97 in Quarters of the High School Classes.

	1	2	3	4	Not Known	Total
Men	3	9	6	35	18	71
Women	2	3	3	5	13	26
Total	5	12	9	40	31	97

2. Why 25 applicants for advanced standing were refused admission to the College of Liberal Arts, Northwestern University in September, 1924.

Causes	Men	Women	Total
Low Scholarship.			
a. Dropped from other institutions	6	1	7
b. Low grades (excessive no. of D's and F's)	6	4	10
Language Deficiencies	3	1	4
Mathematics Deficiencies	1	0	1
Dishonesty at another institution	1	0	1
Combination Causes*	1	1	2
	18	7	25

II—PERSONS ADMITTED ON CONDITION

Note: The data in this section apply to the school year 1923-24.

TABLE IV.

Number of Admissions.

	1st Sem.	2nd Sem.	Total
Number of Students entering.			
Freshmen	601	52	653
Advanced Standing	260	56	316
Total	861	108	969
Number of students conditioned in			
Foreign Languages	177	19	196
Electives	16	0	16
Total	193	19	212
Percent conditioned of total entering	22.4%	17.6%	21.8%
Percent language conditions were of the total number of conditions	91.7%	100 %	92.4%

Out of the total number who were conditioned in language, 169 were Freshmen. This was 23.3% of all the Freshmen.

According to the College Blue Book for 1923-24 (pages 52 and 60) there is no other college or university in Illinois that has as large a percent of its Freshmen condi-

*In these two instances the deficiencies were in both mathematics and foreign languages.

tioned as has Northwestern. The next highest reported is the State University with 15%.

The number of units of language deficiency is shown in the following distribution:

TABLE V.

No. of Units	No. of Persons
½	10
1	156
2	2
—3	1

The two students who entered with two units of condition each had studied languages not on the list accepted at Northwestern. The one with three units had received his training in a foreign country.

The part of each of the two groups that was placed on probation for poor scholarship during the year was,

126 or 19.7% of all Freshmen.

32 or 18.9% of the conditioned group.

TABLE VI.

Scores in the mental alertness tests.

Measure	Conditioned in Language	All Freshmen
Mean	52.2	52.2
Median	52.2	53.2
S. D.	10.29	10.50
Q. D.	7.31	6.62

The standard of scholarship maintained by each of these two groups:

Point Average— .666 conditioned.

1.066 Freshmen.

The difference is accounted for partly at least by the distribution of these groups in the respective quarters of their high school classes.

TABLE VII.

H. S. Quarter	Conditioned Group	All Freshmen
1 (highest)	17%	28%
2	23%	17%
3	25%	15%
4	4%	6%
Unclassified	31%	34%

The above data would not be so significant except for the noticeable scholastic superiority shown by students

ranking in the first quarter. The relation between quartile grouping of students in high school and scholastic success in college has some light shed on it by the following data:

In the year 1919-20 there were 72 fourth quarter high school students who entered Liberal Arts as Freshmen. According to their scholastic success in college they may be classified in the following manner:

4 graduated from Liberal Arts with slightly better than a C average.
1 graduated with slightly less than a C average.
7 transferred to other N. U. colleges with less than a C average.
4 transferred to other institutions with an average of C or above.
18 transferred to other institutions with less than a C average.
2 dropped college work entirely, with better than a C average.
36 dropped college work entirely with less than a C average.

A study of the 4th quarter students of the class of 1925, made after three semesters of work had been completed in college, showed the following distribution:

2 were doing work just above a C average.
14 were still in Liberal Arts but had less than C average.
3 had withdrawn with better than a C average.
13 had withdrawn while failing.
13 had been excluded.

Careful studies of large groups of Northwestern students through their four years of college work show that relative standing of all quarters remains the same between high school and college.

III—COMPARATIVE ENTRANCE REQUIREMENTS IN OTHER HIGHER EDUCATIONAL INSTITUTIONS

TABLE VIII.

1. Entrance Requirements in English, Mathematics and Foreign Language in the Conference Institutions.

School	No. of H. S. Units	No. of Units of For. Lang. none (a)	No. of Units of English	No. of Units of Math. none (a)
Chicago University	15	specifically	3	specifically (b)
University of Illinois...	15	2	3	2
Indiana University	16	2	3	3
Iowa University	15	none	3	2
University of Michigan.	15	2	3	2
Minnesota University ..	15	none	3	2
Northwestern University	15	3	3	2
Ohio State University..	15	none	3	0
Purdue University	15	none	3	2½
Wisconsin University ..	15	none	2	2

(a) Three or more units as a principal sequence, and two or more units as a secondary sequence must be selected from separate single groups among the following: (a) Greek, (b) Latin, (c) Modern Language, (d) History, Civics, Economics, Commercial Geography, Commercial Law, (e) Mathematics, and (f) Natural Sciences.

(b) Two and one-half for Chemistry and Chemical Engineering Students.

2. Comparative entrance requirements in English, Mathematics and Foreign Language.

A. Comparative Requirements in the United States. Data for the construction of Figs. 1, 2 and 3 were obtained from the College Blue Book for 1923-24, page 8. In each distribution ½ units were classified with the preceding whole unit, e. g. a school requiring 3½ units is classed with the group requiring 3 units. Averages were computed from the distributions given in the Blue Book.

B. Comparative requirements in the North Central Area.

Data for the construction of Figs. 4 and 5 were obtained from the College Blue Book for 1924, pages 9 and 10.

Forty-eight percent of 544 schools in the United States prescribe the language to be offered at entrance. Data are lacking for the number that make such prescription among members of the North Central Area.

IV—GENERAL SCHOLASTIC ABILITY AND FOREIGN LANGUAGE STUDY

I—FINDINGS IN THE REPORT OF THE CLASSICAL INVESTIGATION

Part One, "The General Report," came from the press in September, 1924. Its findings apply very largely to the teaching of Latin. Most of the findings give no direct evidence of the comparative value of studying Latin for different lengths of time.

1. Of the eight "Instrumental and Application Objectives", evidence is offered in one, "Increased ability to learn the technical and semi-technical terms of Latin employed in other school studies and in professions and

vocations." One study shows that "the student's chances of success in first year French in college are slightly increased in proportion to the number of years he has studied Latin in school" (page 54). Another study draws similar conclusions for both French and Spanish (page 54).

2. Of the four "Disciplinary Objectives" evidence is offered in one, "The development of certain desirable habits and ideals which are subject to spread, such as habits of sustained attention, orderly procedure, overcoming obstacles, perseverance; ideals of achievement, accuracy and thoroughness; and the cultivation of certain general attitudes such as dissatisfaction with failure or with partial success." One study shows "that successive courses in Latin exhibit a very close inner relationship and therefore are more effective for the cumulative development of habits essential to the study of Latin" (page 58). A supplementary study shows "that there is a higher correlation between marks in first-year Latin and marks in other subjects in the three years following than is true of any other first year subject" (page 58).

3. Of the eight "Cultural Objectives" evidence is offered on two.

A. There is "a marked superiority of three year Latin pupils over non-Latin pupils of the same general scholastic ability in their knowledge of outstanding historical facts connected with the content and background of Caesar's Gallic War and of the orations of Cicero commonly read. The superiority of two-year Latin pupils over non-Latin pupils in the section of the text covered with the content and background of Caesar's Gallic War was somewhat less marked. The degree of attainment of the three-year and two-year Latin pupils as compared with the non-Latin pupils of the same general scholastic ability was found to be nearly the same in the case of those high school pupils who had studied history" (pages 64, 65). The results of one test "on the content and background of Caesar's Gallic War, with Latin and non-Latin pupils who were completing their second year of high school, show an average superiority on the part of two-year Latin pupils over

non-Latin pupils although this superiority is very slight in those portions of the test concerned with the longer historical implications of the text" (page 65).

B. The second cultural objective concerned was, "Increased ability to understand and appreciate references and allusions to the mythology, traditions, and history of the Greeks and Romans. Data show that Latin pupils make little growth in this ability in the first two years, although they make a large gain in the last two years" (page 67).

II—A STUDY OF NORTHWESTERN STUDENTS

A. The following table shows the mean of point average of groups of students taking certain foreign languages:

TABLE IX.

No. of Students	Language	Mean Point average in other subjects.
269	Latin	1.4600
266	Spanish	1.0125
75	German	1.0450
656	French	1.0725*

B. The following table shows the coefficient of correlation between marks in each of the foreign languages pursued in Northwestern, and certain other subjects:

TABLE X.

No. of Students	Subjects considered	Correlation figure.
260	Spanish and English	.22
26	Spanish and French	.59
266	Spanish and all other subjects	.41
656	French and other subjects (not including mathematics)	.40
164	French and Latin	.44
667	French and English	.41
75	German and other subjects	.46
269	Latin and other subjects	.48
656	Mathematics and other subjects (not including French)	.41
169 Freshmen	Language and all other Freshman subjects	.44

C. The following table gives a display of information similar to the above, but for subjects other than foreign language. It is given in order to determine whether such comparisons show peculiar similarity between scholastic ability and language ability only, or whether similar correlation exists between other subjects.

*Mathematics is not included in the other subjects in this figure.

TABLE XI.

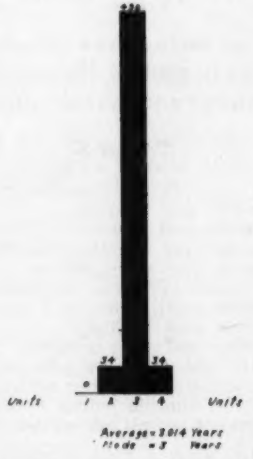
No. of Students	Subjects Correlated	Correlation figure
858	English and Mathematics	.31
858	English and other subjects (not including mathematics)	.41
858	Mathematics and other subjects (not including English)	.43

V—SUMMARY

1. The present foreign language requirement is one of the two highest ranking causes for rejection of those who apply for admission as Freshmen. It is outranked only by poor scholarship. It is also second in rank as a cause for rejection of applicants for advanced standing. (Table I.)

2. The foreign language requirement is the cause of the conditioning of new students in more than 90% of those who are conditioned. (Table II.)

FIG. 1
ENGLISH ENTRANCE REQUIREMENTS OF 338 INSTITUTIONS IN THE UNITED STATES.



3. Northwestern has the same English entrance requirements as that of the large majority of schools for the entire country (Fig. I), and it is believed for the North Central Area also, although at the time of writing this report data for the last group were not available.

FIG. II
MATHEMATICS ENTRANCE REQUIREMENTS OF 341 INSTITUTIONS IN THE UNITED STATES

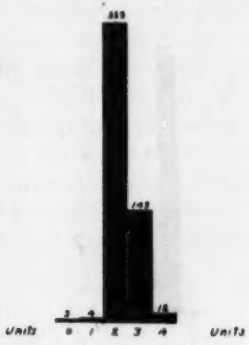
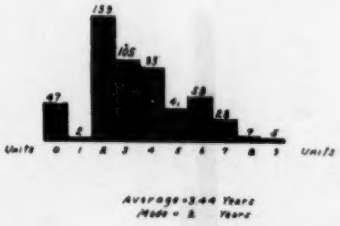


FIG. III
FOREIGN LANGUAGE ENTRANCE REQUIREMENTS OF 345 INSTITUTIONS IN THE UNITED STATES



In mathematics entrance requirements Northwestern is below the average for the entire country (Fig. II) and with the marked majority in the North Central Area. (Fig. IV.)

The three year foreign language requirement places Northwestern below the average, but about the modal group in the entire country (Fig. III), and above both the average and the mode in the North Central Area. (Fig. V)

Among the conference schools Northwestern stands by itself in language requirements, and in language alone. (Table VIII.)

FIG. IV
COLLEGE ENTRANCE REQUIREMENTS IN MATHEMATICS OF 207 INSTITUTIONS IN NORTH CENTRAL STATES.

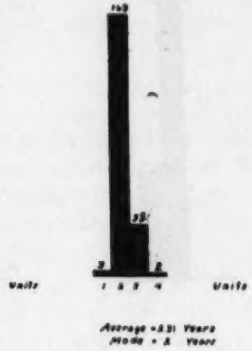
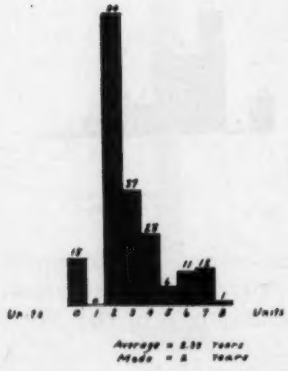


FIG. V
COLLEGE ENTRANCE REQUIREMENTS IN FOREIGN LANGUAGE OF 199 INSTITUTIONS IN NORTH CENTRAL STATES



4. The report on the Classical Investigation gives information so meager as to be unconvincing, if not negligible, in any attempt to answer the question whether our present language requirement is educationally sound.

5. The study of correlations among Northwestern students, in so far as it is conclusive, reveals no superiority of any particular subject as the measure of

scholastic ability or achievement. The fact of a nearly uniform level of correlations, no matter how the subjects are paired, only suggests that ability or achievement (or lack of it) in one subject is more likely than not to be accompanied by ability or achievement (or lack of it) in other subjects. (Tables X and XI.)

6. Superior Scholarship in College in any group is to be accounted for in terms of native ability far more than in terms of any special subject studied. The most reliable measures of the ability known at present seem to be intelligence tests and high school scholarship.

PHI BETA KAPPA STUDENTS AT NORTHWESTERN UNIVERSITY

WHAT THEY BRING AND WHAT THEY TAKE

WENDELL S. BROOKS, NORTHWESTERN UNIVERSITY

A detailed study of:

I. The units offered for admission to the College of Liberal Arts, during the decade 1909-1919, by candidates who were subsequently elected to the Phi Beta Kappa Society.

II. The quality of the high school work that had been accomplished by these candidates.

III. The courses they pursued in college to earn their bachelor degrees as members of the classes of 1913-1922.

Colleges and universities will presently have to justify their appeals for support, both financial and personal, by showing unmistakable evidence of the effective work they are accomplishing. Not much has yet been done in this direction by college administrators. One, recognized as a leader in college circles, said in his recent inaugural address:

"The dividends of the university, though enormously valuable, are indefinite, intangible, indirect and often deferred, and a man accustomed to commercial comparisons becomes confused, hesitant or even frankly doubtful."[1]

The longer college and university administrators continue to emphasize the indefinite results of the education which they are administering, the wider will become the breach between secondary schools and higher institutions. College men must reach better agreement as to their objectives and then set such requirements for admission and arrange such work in the college course as will secure men and women for the college best fitted to profit by its curriculum and, through it, to achieve finally the objectives of the college.

Cubberley[2] wrote a decade ago: "Our school authorities are not likely to know too much about what they are doing, or what the work attempted is costing. Such information should be tabulated and charted and made as useful and intelligible as possible. Much of the material

[1]Brooks, Stratton D., School and Society, Vol. XVIII, No. 464.
[2]Cubberley, Ellwood P., *Public School Administration*, p. 425-6.

collected will be capable of graphic representation, and the presentation of facts in graphic form will always prove helpful and stimulating."

In his text on "Measurement in Higher Education", Ben D. Wood, Assistant Professor of Collegiate Educational Research in Columbia College, devotes a chapter to discussion of the question: "What is College Success?" He recognizes college life as "a very complex and variable phenomenon" but insists that "whatever exists at all exists in some quantity or amount. The effort to measure the quantity of a phenomenon is but an extension of the effort to learn what it is. * * *The college * * * has certain special characteristic functions which distinguish it from other institutions the performance of which may be said to measure its success as a distinctive institution."

The author then enumerates and justifies four major activities of college life, viz.: (1) Participation in physical competitions whether in grandstand or in the game is one of the finest elements of collegiate experience. (2) The development and encouragement of conduct, habits and attitudes that are socially desirable * * * is a prominent function of a college. (3) Professional preparation for leadership in the work of the world is an end which our liberal colleges of today are unashamed to serve. (4) What might be regarded the most important characteristic function of the college is the introducing of students into what President Butler has happily called "The Great Tradition". * * * This is the *raison d'etre par excellence* of the college, and the main line of attack is the academic one. Since this is so, we may lay down the general principle that the most important measure of college work is its academic product. In turn, this product is dependent in large part upon the preparation prior to entrance.

I.

If the *sine qua non* of the college is its academic work, as Professor Wood insisted above, those who have accomplished this academic work in such a manner as to win the highest approval of the faculty may be assumed to

have achieved the largest college success. Election to the Phi Beta Kappa Society is commonly regarded as the highest scholastic honor because it is based primarily upon the scholarship record made by students in college.

The first part of this report, therefore, surveys the preparatory work of all those students who through the ten-year period were awarded this distinction. The number so honored was 269. Each college class, from 1913 to 1922 inclusive, was studied separately.

A summary of the decade leads to the following conclusions:

1. Of those elected to Phi Beta Kappa at Northwestern University during that decade, 70% entered college with more than the minimum requirement.

2. Ditto, 24% entered with at least two extra units of preparatory work.

3. The average amount offered was 16.12 units.

4. The content of this average offering was:

TABLE I.

Distribution of Units offered for entrance by candidates subsequently elected to Phi Beta Kappa.

Field of Study	Number of Units	Proportion of Total Offered
English (3)	3.28	20.37%
Algebra (4)	1.45	9.00
Plane Geometry (5)	1.00	6.21
Foreign Language (6)	5.49	34.09
Science (7)	2.22	13.78
History (7)	1.80	11.18
Other Academic	.63	3.91
Manual and Commercial	.23	1.42
	16.10	99.96

5. Only 2 students, of the 269 who made Phi Beta Kappa that decade, entered "on condition". (Each was conditioned in one unit only.)

From the standpoint of quantity the study shows that the future Phi Beta Kappas offered (1) considerably

[3]Entrance requirement in English 3 units, throughout the decade.

[4]Algebra requirement reduced in 1911 from 1½ to "1 or 1½," and in 1914 to 1 unit.

[5]Plane geometry—one unit.

[6]The foreign language requirement stood at 4 units during the first half of the decade; was reduced in 1914 to 3 or 4 units," and in 1918 to 2 units. (In 1919 it was changed to 3 units of one language or 2 units of each of two—the present requirement.)

[7]The requirement of one unit each of science and history was discontinued in 1910.

more than the minimum total requirement for entrance and (2) considerably more than the minimum requirement in the various prescribed subjects.

II.

From the standpoint of quality the preparatory records available at the University were practically worthless. Everyone knows the wide variations in teachers' markings. An 85 on one entrance record may represent more and better work than a 95 on another. Individual marks mean little, but numerous studies* have shown that the standing in the high school graduating class is of value in predicting the probable success in college of a prospective candidate. The writer, therefore, addressed all the schools which had prepared for college the 269 students concerned. From 21 different states and from Ontario, 132 different schools were sending of their best scholars to Northwestern to become Northwestern's Phi Beta Kappas.

TABLE II.

Location and number of different schools in which preparation for College was completed by students elected to Phi Beta Kappa at Northwestern University from the Classes of 1913-1922 inclusive.

California	1	Missouri	7
Colorado	2	Nebraska	1
Illinois	65	New York	1
Indiana	7	North Dakota	1
Iowa	10	Ohio	3
Kansas	2	Ontario	1
Kentucky	1	Oregon	1
Massachusetts	1	South Dakota	1
Michigan	13	Tennessee	3
Minnesota	1	Washington	3
Mississippi	1	Wisconsin	6
Total different schools			132
Schools—U. S.	131	Public schools	118
Schools—Foreign	1	Private schools	14

A simple request was made of the schools, viz. "Indicate in which quarter of his (or her) high school class

*Brooks, Wendell S. "Our Freshmen" *Carleton College News Bulletin*, March, 1922.—Clark, Edward L. An unpublished study shows that "of 72 fourth-quarter high school students who entered Northwestern in 1919, only 5 have graduated."—Dearborn, W. F., "The Relative Standing of Pupils in the High School and the University." *Bulletin of the University of Wisconsin*, No. 312.—Palmer, Paul L. "Some Experiments with Mental Alertness Tests at Northwestern University" *School and Society* Vol. XVIII, No. 462.

each of your former students named hereon stood at graduation."

In view of the many years that have passed since members of the college class of 1913 began high school, the frequent changes in high school principalships, the inadequate records in many schools and the loss of records in a few, it is felt that to have received a definite answer regarding 161 students (though barely 60% of the total 269) is rather gratifying.

Of the 161 reported, 144 (89%) had stood in the top quarter of their high school graduating class and the remaining 18 were members of the second quarter. Not a single man or woman, who made Phi Beta Kappa at Northwestern through the entire ten years surveyed, was reported as having stood in the lower half of his or her high school class!

Although only the one question had been asked them, several school authorities volunteered additional information from which I gather numerous "valedictorians," "salutatorians," and "cum laude's;" some expressions of appreciation as "best student ever in • • • high school," "and high in first quarter," "top 5%," "among highest seventh," etc. A feeling of civic and professional pride may have prompted this remark: "one of the best graduates the school ever turned out."

Clearly, that part of the high school product of which Phi Beta Kappa men and women are made in college is of fine character.

We see then that from the point of view of quantity they did more in high school than was required of them, and, as to quality, they did far better than required.

III.

In the preface to his volume on *Administration of the College Curriculum*, William Trufant Foster wrote: "In the archives of Harvard College alone are the records of nearly half a century of elective studies. Here is a well-equipped laboratory awaiting students of higher education. Interpreted by proper statistical methods, these records can give guidance in the administration of the college curriculum beside which the opinion of any man,

or any body of men, is insignificant. Yet such records have not been asked to tell a tenth of what they know. The criticism of the American college, which has been so abundant of late, has yielded a hundred opinions to one fact."

Following President Foster's recommendation in an effort to get at the fact, the writer examined the college scholarship record of each of the 269 students. The total number of hours credit earned toward graduation in each department of study by each of the 269 students was found. Addition showed the hours credit in each department earned by all the Phi Beta Kappa students of a given college class. A four-year period is rather brief to give a really representative view of the status of departments in a long established college, so the records of the ten classes were summed up with the following results.

TABLE III.

College courses taken by those elected to Phi Beta Kappa in Northwestern University Classes of 1913-1922, inclusive.

Subject of Study	No. of Semester Hours Credit		Percentage of Total Earned for Graduation	
Academic				
Art	177		.511	
Astronomy	139		.402	
Biblical Literature	362		1.047	
Botany	1073		3.103	
Chemistry	1283		3.710	
Economics	1557		4.503	
Education	1372		3.968	
English	5292		15.306	
French	3663		10.594	
Geology	754		2.180	
German	3343		9.669	
Greek	926		2.678	
History	2631		7.609	
Latin	2857		8.266	
Mathematics	2497		7.222	
Philosophy	607		1.755	
Physics	715		2.068	
Political Science	177		.511	
Psychology	1729		5.001	
Spanish	360		1.041	
Zoology	1089		3.149	
Total	32603		94.293	
Other Academic (9)	179		.517	
Total Academic		32782		94.810

[9]History of Religion, Italian, Religious Education and Scandinavian.

Subject of Study	No. of Semester Hours Credit		Percentage of Total Earned for Graduation	
Professional				
Commerce	48			
Dentistry	30			
Engineering	292			
Journalism	3			
Law	241			
Library	30			
Medicine	131			
Music	128			
Speech	714			
Theology	59			
Total Professional		1676	4.805	4.805
Military Training (10)		115	.332	.332
		34573		99.947

A summary of the semester hours' credit earned by this group shows:

Academic	32782
Professional	1676
Military Training	115
Total hours earned	34573
No. of Phi Beta Kappa Students	269
Average number of hours earned	128.52
Graduation requirement	120
Excess earned per student	8.52

Grouping certain subjects for the attention of those particularly interested in a given field of study, we have:

Subject	Percent of Total Credit		Subject	Percent of Total Credit	
Sciences and Mathematics			**Foreign Languages**		
Astronomy	.402		French	10.594	
Botany	3.103		German	9.669	
Chemistry	3.710		Greek	2.678	
Geology	2.180		Italian	.260	
Physics	2.068		Latin	8.266	
Zoology	3.149		Spanish	1.041	
		14.612			32.508
Mathematics	7.222	7.222			
		21.834			
English	15.306		Education	3.968	
			Philosophy	1.755	
Social Science			Psychology	5.001	
Economics	4.503				10.724
History	7.609				
Political Science	.511				
		12.623			

10Credit awarded 9 men in classes of '18, '19, and '20.

A representative Phi Beta Kappa student at Northwestern the last ten years is thus seen to have earned nearly 22 percent of his credits in the field of science and mathematics, 15 percent in the English language and literature, 32 percent in various foreign languages, 12.6 percent in the social sciences, 10.7 percent in education, philosophy and psychology, and 4.8 percent in various professional subjects.

TABLE IV.

Distribution of Studies pursued by members of Phi Beta Kappa

Field of Study	For Entrance	For Graduation
English	20.37%	15.31%
Science and Mathematics	28.99	21.83
Foreign Languages	34.09	32.51
History and Social Science	11.18	12.62
Other Academic	3.91	12.54
Manual, Commercial, Professional	1.42	4.81
	99.96	99.62[11]

With all due respect to those who would continue helping the under dog, it is the belief of the writer that if our colleges and universites are to justify themselves they must secure for higher study a larger proportion of the best students in secondary schools. They must then provide for these superior minds standards of scholarship in college which will exercise them to the full. If a chairman or any professor finds that his department has not had its share of those students to whom the faculty has awarded highest scholastic honors, he may well inquire as to the inspiration of his teaching or the standards of his department.

Starch reported a study of elementary pupils which indicated that one pupil in a hundred could complete the work of the eight grades in four years and twenty-one in a hundred could do the eight years' work in seven.[12] Our colleges receive not average young people but a select group, of whom this study evidences that the best do more and better work than is expected of them. If, therefore, a college department has in it many of these best qualified students, inquiry should be directed to the

[11]Add .33 allowed for military training to make total 99.95 for column.
[12]Starch, Daniel. *Educational Psychology*, p. 39.

methods of teaching, the initiative expected of these students, the assignment load. For such students are capable of much self-direction[13] and lose interest if the load be not commensurate with their strength.

[13] "By vote of the faculty of Williams College on February 9, Phi Beta Kappa seniors are not limited in the number of absences allowed in their regular college subjects so long as their work is satisfactory." *School and Society*, February 21, 1925.

A PLAN FOR EXTRA INSTITUTIONAL CARE OF FEEBLE-MINDED GIRLS

ANNA POLKOWSKI, LINCOLN STATE SCHOOL AND COLONY

The higher type of feebleminded girl can be trained to work well under supervision. At the Institution we have girls who can sew well, do housework well, help in the kitchens, help dress and feed the children, etc. In 1919 we had many of these girls who could work well but who were dissatisfied. Without any future, except continued residence in an Institution, is very discouraging to a feebleminded adolescent or adult. Because of this outlook there didn't seem to be much incentive to work well or behave well, if there was to be no extra compensation. Discontent resulted and behavior problems arose which were not easily coped with. A possible solution appeared when it was decided to try one of the most troublesome girls as well as the best worker, in a downtown hospital. This girl seemed a good possibility because she had an I. Q. of .90. She justified the belief in her ability by making good for two years, 3 months, when she was discharged to relatives. Since we had success with a very troublesome girl, we decided to parole others who were good workers, of our highest group of mentality, and who, considering all factors, we felt would make good. In 1919 two girls were paroled, and the number increased until in 1924 we had 77 on parole.

The plan as carried out at Lincoln is as follows: Hospitals or private homes that desire a girl for housework, or similar work, apply to the managing officer. He interviews the applicants and chooses the girls who are to go. Girls who are good workers at the Institution and who behave well here, or who he thinks will behave well when out, are the ones who are paroled. Instructions and advice are given prospective employers and also the patient. The salary for the girls is $3.50 a week including room and board, except if they are to be employed on a farm, where because of the harder work, they are to get $4.00 a week including room and board. The girl is paroled for an indefinite time, good behavior being the criterion of the length of her stay. If the employer is dissatisfied with the work or behavior of the girl he can return her.

If, for any reason, the girl does not like her place she may come back. The employer comes for the girl and also returns her. The wages of the girl are put in our trust fund to her credit. Her clothing and pin money are taken out of her account. As a rule the girls get from $1 to $5 a month for spending money. The minimum chronological age of the girls sent out is 18 years.

In order to find out, definitely, just how our plan is working, we sent questionnaires to the girls' employers, and these, together with our records, constitute the basis of our statement of results. This study is based on an analysis of the records of 151 girls who have been on parole for some time during the last five years. We divided these 151 girls into 4 groups, somewhat arbitrarily and yet in order of their ability to make good. The first group consists of 60 girls who have been on parole and have never been returned, that is, they are making good, and we have not had to recall them to the Institution. The second group consists of 18 girls who have been returned to Lincoln but at the present time are out working again. The third group consist of 42 girls. These were out to work but proved unsatisfactory, were returned to Lincoln and are here at the present time. The fourth group consists of girls who were out to work but have now left the Institution, that is, they are either on parole to their own homes, on escape, or have been discharged. This group consists of 31 girls. We will discuss our results in terms of these 4 groups.

The factors that we believe would have an influence on the patients' ability to make good are: mental age, chronological age, behavior of patient while in the Institution, and the length of stay in the Institution previous to being paroled. We find the following results:

1. As to mental age
   a. Of the first group, those who are on parole and have never been returned,
      39% had an I. Q. of less than .50.
      61% had an I. Q. of .50 or more.
   b. Of those in the second group,
      33% had an I. Q. of less than .50.
      67% had an I. Q. of .50 or more.

c. Of the third group,
   52% had an I. Q. of less than .50.
   48% had an I. Q. of .50 or more.
d. The fourth group,
   24% had an I. Q. of less than .50.
   76% had an I. Q. of .50 or more.

We find, then, that the chances for getting along on parole are better for the moron than the imbecile.

2. As to chronological age,
   a. The median age of the 1st group is 27 years.
   b. The median age of the 2nd group is 25.5 years.
   c. The median age of the 3rd group is 24 years.
   d. The median age of the 4th group is 20.5 years.

In general then, the older girl makes good on her initial trial. The younger girl needs more than one trial before she can adjust properly.

3. In considering the behavior of the patient while in the Institution, we find that girls who behave well here, and also did their work well, were able to do the same when on parole. If they behaved badly here but yet were excellent workers, they came second in ability to make good. But those who were well behaved but only fair workers here were incapable of making good when paroled. Employers would tolerate a good worker even tho badly behaved in preference to a poor worker but well behaved.

4. Regarding the fourth factor as to length of stay of a patient in the Institution previous to being paroled, it was found that those of group one had been in the institution the longest. Group 2 came second in length of stay here. Since the majority of these girls are working in hospitals which are in themselves institutions, we would expect the more highly institutionalized girl to get along better. Other factors, such as previous training in housework before coming here and the fact that the patient has children in Lincoln for whom she might want to buy a few extras, would help her get along better on the outside.

As a summary of the factors influencing the patient's ability to make good we may say first, that the girl with an I. Q. of .50 or above, has the better chance; second, the older girl makes good the first time, the younger

girl needs a change of place before making a good adjustment; third, if a patient behaves well while in the institution, she will also behave well when on parole; and fourth, girls who have been at the Institution longer get along better when placed out to work.

Our primary consideration in sending girls out to work was because it made them more contented. We thought they would be happier earning their own living, and having nicer clothes, and money to spend which they could not have at the Institution. We find that the girls are happier and consider going out to work a privilege. But we now find that in addition to the girls' greater contentment, there is an economic advantage to our plan. We will give the figures which will make this advantage self evident. The total amount of money saved while the girls were on parole, exclusive of 13 accounts which are of girls that have been transferred to other Institutions or have not been settled, is distributed as follows:

Group 1	$7,363.34
Group 2	1,363.74
Group 3	1,841.80
Group 4	1,745.59

The grand total is $12,314.47. Besides this money that they have saved, they have paid for their clothes and other incidentals and have earned their board and room. While these girls are on parole they do not cost the State anything. The average cost per capita of clothing, feeding, and housing a patient at Lincoln is about $285. We have estimated roughly that these girls while on parole save the tax payers a lump sum of $51,000.

Our plan, then, altho in an experimental stage, justifies its existence both as to the greater happiness it gives our girls and also its economic value.

RELATIVE VALUE OF DIFFERENT TYPES OF QUESTIONS IN READING TESTS

STERLING G. BRINKLEY, ILLINOIS COLLEGE

The Problem.

The subject of this study is narrower than is indicated by the title given it. "Reading tests" are limited to silent reading tests of the type of the Thorndike-McCall Reading Scale, designed to measure depth of power of comprehension in reading. Only three "types of questions" are considered: the true-false, the multiple choice or selective response, and the word or phrase answer type. The comparison of "value" is limited to one point, that of validity or the extent to which the test measures the ability it is supposed to measure. The question studied may then be more accurately stated as follows: What is the relative validity in a silent reading test of the kind indicated of true-false questions, multiple choice questions, and word or phrase answer questions?

This study of the types of questions for reading tests is a phase of a larger problem undertaken two years ago. When Professor W. A. McCall of Columbia University was serving as Director of Psychological Research for the Chinese National Association for the Advancement of Education, I undertook in coöperation with this organization the construction of an English reading test. As previous use of the Thorndike-McCall Reading Scale in Chinese schools had demonstrated its value for measuring reading and general English ability where English was a foreign language, my procedure was to adapt this test to the situation. In doing this all poetry was omitted, new reading selections were introduced, all duplication of selections in parallel forms of the test was eliminated, the vocabulary was zoned on the basis of Thorndike's Teachers Word Book, and idioms likely to cause unusual difficulty to the foreign student were changed. In order that the test might involve only reading, it was decided to construct questions of the multiple choice type. Thus the written answer was avoided. Four forms of the reading test were constructed and standardized for Chinese schools.

The problem of the validity of the multiple choice type of test was raised by this larger study. Data bearing on its solution were gathered, but it is only recently that there has been opportunity to go back to the original data collected and complete the study.

The Tests Used in the Study.

The following sample taken from Form I will illustrate the types of questions compared. The paragraph chosen is one of the easier paragraphs, containing only words from Thorndike's first 500 in frequency of occurrence.

Once there was a rich man who got up early one morning and placed a great stone in the road. He wanted to see what people would do when they saw it. That day he saw men, women, and children pass by. Each one looked at the stone and then walked or drove around it. At last, just at dark, a boy came along. He said to himself: "Someone may fall over this stone. I will try to move it." He worked and worked until he moved it away. Then he saw a box which had been lying under the stone. When he opened the box, he found that it was filled with gold.

Type A questions, (Multiple Choice, from Form 2A).

1. The stone was placed in the road (a) by the rich man, (b) by a boy, (c) by a group of people, (d) by some children.
2. The box of money was found (a) under the stone, (b) in a house, (c) by the side of the road, (d) in a hole in the ground.
3. Why did the boy move the stone? (a) Because he thought some one might fall over it. (b) Because he wished to see if he could move it. (c) Because the people would all know about it. (d) Because he wished to find some money.
4. Most of the people who passed along this road (a) tried to move the stone, (b) moved the stone, (c) fell over the stone, (d) went around the stone.

Type B questions, (Word or Phrase Answer, from Form 2B).

1. Who placed the stone in the road?
2. Where was the box of money found?
3. Why did the boy move the stone?
4. What did the men do when they saw the stone in the road?

Type C questions. (True-False, from Form 2C).

1. Was the stone placed in the road by the boy?
2. Was the box of money found under the stone?
3. Did the boy move the stone away?
4. Did the people who passed along this road fall over the stone?

It is evident from the reading of the different types of questions that for any given paragraph the questions of one type cover the same facts as are covered by the questions of the other two types. This is true of the tests as a whole. The paragraphs of Form 1 were thus used in three tests, Type B having the word or phrase answer questions, Type A having the multiple choice questions, and Type C having the true-false questions.

Similarly, there were the three types of questions grouped in three separate tests for Form 2 and for Form 3.

Forms 1A, 2A, 3A (that is, Forms 1, 2, and 3 of the reading test in each of which the Type A, or multiple choice questions, were used) were of equal difficulty, as determined by results got when they were administered to a group of 100 pupils. The arithmetical means were respectively 25.6, 24.9, 24.1. It was assumed that this same approximation of equality between the forms existed in the case of the Type B and Type C questions also. The three forms with the Type A questions had a length of 50 minutes (the average time used by the pupils in taking the test). The length in minutes for the Type B and Type C tests was not determined. The number of items was, of course, the same as in the Type A tests.

The Criterion.

The study undertook to determine the relative validity of the three types of questions. Validity is determined by comparison with a criterion. Two types of criteria were possible. (1) The first was a composite of the scores on the three reading tests which were being compared. The advantage of this criterion is that it is a criterion of *reading ability;* its disadvantage lies in the fact that spurious correlation is present due to the inclusion in the criterion of the test studied. (2) The second was a measure of *general ability* in English. The English department gave at the close of the semester six standard tests covering varying phases of English ability. These were: Thorndike-McCall Reading Scale, Kelley-Trabue Completion Test, a spelling test made up from Ayres Spelling Scale, and three tests of the English Mastery Series published in Shanghai, i. e., Grammar-Idiom, Word Opposites, and Auditory Comprehension. A composite of the results on these six tests was made, by giving to spelling and auditory comprehension each a weight of one-half while each of the other tests received a weight of one. This composite was, it is believed, a very accurate measure of general ability in English.

A previous study[1] had shown fairly high correlation between ability in reading as measured by the Thorndike-McCall Reading Scale and general English ability. This fact was taken to justify the use of the composite as criterion, while the fact that none of the tests being compared was directly included in the composite led to its acceptance in preference to the more specific reading criterion.

The Subjects.

The subjects in the experiment were the pupils of the Soochow University Middle School[2]. Only those who took all the tests were included in the final computations. The number was 226. The school is a college preparatory school for boys. The course of study covers seven years. English is begun the first year and is compulsory throughout the course. For the purpose of the experiment the pupils were divided into two major groups, Group I and Group II. Group I was composed of the pupils who had taken the original forms of the reading test, Type A, in April, when it was administered for purposes of try-out and scaling. The remainder of the pupils of the school made up Group II.

The pupils of Group I were divided into two sub-groups, designated as V and W. The division was carried out by the method of pairing so as to render the groups of equal ability in English. The pupils of Group II were divided into three sub-groups in the same way. These groups were designated as X, Y, and Z. That the sub-groups within each major group were closely similar groups is seen by the fact that the averages and standard deviations of the scores made by these groups on the criterion composite are almost identical. (Table I.)

[1] Brinkley, The use of American tests to measure English teaching in China, *Journal of Educational Research*, Sept. 1923, Vol. 8, No. 2

[2] Located at Soochow, China

TABLE I.

AVERAGES AND STANDARD DEVIATIONS.

	No. of Pupils	Criterion Mean	Criterion S. D.	Type B Mean	Type B S. D.	Type A Mean	Type A S. D.	Type C Mean	Type C S. D.
Group I.									
Sub-Group V	50	104.7	25.9	28.3	10.4	25.0	12.1	28.3	12.1
Sub-Group W	49	104.5	26.5	32.1	11.9	25.9	12.1	28.1	12.3
Group II.									
Sub-Group X	40	104.2	16.9	23.2	6.3	27.9	8.2	24.2	7.0
Sub-Group Y	44	104.6	17.0	29.4	6.3	23.6	7.1	24.9	8.9
Sub-Group Z	43	104.1	16.7	27.5	7.0	25.0	7.0	26.8	7.8
Arith. Mean (unweighted)				28.1		25.5		26.5	

NOTE.—The pupils in each Group were drawn from all the seven classes in the school, except that in Group II. there were no pupils from either the lowest or the highest class.

Administration of the Tests.

With one exception the tests were administered at the close of the semester in June, 1923. The exception was in the case on Group I which had taken the Type A tests in April. In June this group was given Form 1B and Form 1C, and the scores made on Form 1A in April were compared with these. The two tests in June were given during one two-hour period. The order of giving the two tests was rotated in order to eliminate the probable practice effect due to the identity of content in the tests and any fatigue effect due to the taking of the two tests at one sitting.

To Group II were administered three tests on two consecutive days, two being given at a two-hour period on the first day. Any specific practice effect was eliminated with this group by using all three forms of the test, making it possible to have different content on each occasion. Thus Sub-group X took as its three tests Form 1A, Form 2B, and Form 3C. In this way no group of pupils had the same paragraphs twice and no two groups of pupils had the same questions. Moreover, there was rotation of types so that there might be eliminated whatever advantage or disadvantage was

present due to the time and order in which the tests were taken. Thus Type A was administered first to Group Z, second to Group Y, and third to Group X. For the first test Group X had Form 2B, Group Y had Form 2C, and Group Z had Form 2A. These illustrations should make clear the type of rotation used.

To sum up: Group I had the same content in all three of the tests taken. For this group the variable factors were type of questions and time and order of taking the tests. The rotation in administering the tests was such as to give the advantage of practice now to one type and now to another. Group II had different content in each of the tests taken, but the difference was only that between parallel forms of the same test; the rotation in administration here served to balance advantages of position and order of tests in the series. Correlations were computed for each of the five groups separately.

As a result of this method of administering the tests, the three types of questions are compared under the following conditions: (1) When the content is the same and the pupils are the same, but the time of taking the test varies (Table II, Group I.); (2) When the content is the same and the time of taking the test is the same, but the pupils are equal groups rather than the same pupils (Table III.); (3) When the pupils are the same, but the content instead of being the same is equivalent (parallel forms of the test), and the time of taking the test varies (Table II, Group II.). It would seem that differences between the tests shown after all these comparisons are combined must be due to the type of question used.

Results of the Study.

The results of the comparisons are shown in Tables II and III. The word or phrase answer test gives in every

TABLE II.

CORRELATIONS WITH CRITERION.

(Pupils, the same: Group I. Content, identical; Group II. Content, equivalent forms).

	Correlations			P. E. of Correlation			No. of
	Type B Word or Phrase Ans.	Type A Multiple Choice	Type C True-False	Type B	Type A	Type C	Pupils
Group I.							
Sub-Group V.	.92	.91	.88	.015	.016	.022	50
Sub-Group W.	.94	.92	.86	.011	.015	.025	49
Group II.							
Sub-Group X.	.84	.80	.67	.032	.037	.059	40
Sub-Group Y.	.89	.83	.85	.021	.032	.028	44
Sub-Group Z.	.84	.78	.82	.030	.040	.034	43
Ar. Mean (unweighted) ...	.89	.85	.82				

TABLE III.

CORRELATIONS WITH CRITERION.

(Content identical; equivalent groups; time and order of taking tests identical.)

	Type B Word or Phrase Ans.	Type A Multiple Choice	Type C True-False
Group I.			
Form 1.....	.94	.92	.88
Form 1.....	.92	.91	.86
Group II.			
Form 1.....	.89	.80	.82
Form 2.....	.84	.78	.85
Form 3.....	.84	.83	.67

NOTE.—The data in Table III are, of course, the same as those in Table II. The separate comparisons made are, however, different.

case except one the highest validity coefficient. The multiple choice test gives a higher coefficient than the true-false test in six out of the ten comparisons and a lower validity in the other four. The average (Table II.) is in favor of the multiple choice test. The differences revealed by the study are not great, whether considered separately or in the average. The data are not of such nature as to make possible the mathematical determina-

tion of the significance of these differences. Since, however, the word or phrase answer test is superior to the other two in every comparison except one, and practically equal there (Table III.), the average difference of .04 between it and the multiple choice test and of .07 between it and the true-false test is more likely to be a *real* difference than that of .03 between the multiple choice test and the true-false test.

The data may be interpreted, therefore, to indicate a slight but real advantage in validity of the word or phrase answer test over the other two and no essential difference in validity between the multiple choice and the true-false tests. These conclusions based on a study of *reading tests* are in agreement with the conclusions of a more thorough study of types of tests in the field of *history* made by the writer[1].

[1]Brinkley, S. G., *Values of New Type Examinations in the High School, with Special Reference to History*. Teachers College, Columbia University, Contributions to Education, No. 161.

VARIABLE FACTORS ENCOUNTERED IN THE RATING OF STUDENTS

JOSEPH V. HANNA, PERSONNEL DIRECTOR, JOLIET TOWNSHIP HIGH SCHOOL AND JUNIOR COLLEGE

In the Personnel Program at Joliet Township High School and Junior College, considerable attention is being given to the rating of students on character qualities. The problem of preserving the ratings in convenient and workable record form presented itself at the outset. Two courses were open to us—that of keeping a record of each separate rating by every teacher, or the somewhat easier method of recording an average of all ratings (of a student on any quality) made at a stated time. The purpose of the study described in the present paper was to test the soundness of the practice of averaging ratings.

Near the close of the first semester of the school year 1923-24, more than sixty members of the faculty rated a large percentage of high school and junior college students on the following general qualities: application, ability to organize, accuracy, punctuality, aggressiveness, and social qualities. A blank was used which presented particular descriptive statements for each degree of each general quality. Preceding the rating several conferences were held with teachers who participated. Teachers were asked to rate only the students in their own classes or groups. Correlations between the ratings of twenty-three pairs of teachers who had rated groups sufficiently large for purposes of comparison were determined by means of the Pearson Product-Moment Formula. Coefficients varied from —.30 for the ratings of an English and an Algebra teacher on social qualities to .89 for the ratings of two stenography teachers on accuracy. A general summary of correlations is presented in Table I.

TABLE I.

Summary of Correlations

*Teacher	Teacher	Application	Ability to Organize	Punctuality	Accuracy	Aggressiveness	Social Qualities	Average
MP[3]	MC[1]	.42	.45	.71	.45	.26	.49	.46
MD[1]	WG[1]	.36	.61	.21	.82	.61	.53	
WM[3]	WHE[2]	.33	.36	.41	.30	.33	.55	.39
WST[1]	WST[2]	.72		.28	.89	.50		.60
WE[2]	WM[3]	.56	.34	.74	.69	.36	.47	.53
WE[4]	WHE[1]	.66	.69	.44	.63	.33		.55
WPS[1]	WH[2]	.52	.70	—.18	.54	.73	.61	.55
MM[3]	MP[2]	.83	.78	.52	.78	.86	.51	.71
MP[1]	WF[1]	.54				.38		.46
MA[c]	WH[2]	.45	.35	.00	.42	.63		.37
WST[1]	WH[1]	—.13	.14	.05	.22	.00		.06
MB[3]	WL[1]	.73	.77	.57	.68		.80	.71
MP[2]	WPS[1]	.22	.74	.00	.43	.69	.43	.42
WE[5]	WG[1]	.64	.45	.87	.59	.28	.73	.51
MP[1]	WPS[1]	.31				.47		.39
ME[1]	WA[1]	.70	.54	.71	.59	.38	—.30	.44
WE[5]	MD[1]	.50	.26	.20	.41	.16	.19	.29
WE[2]	MSC[1]	.74	.24	.31	.47	.22	.20	.36
WM[4]	WL[1]	.44	.59	.35	.49	—.23	.80	.41
WE[5]	WHE[2]	73	.51	.71	.41	.50	.13	.50
ME[3]	MZ[1]	.51	.67	.37	.50	.55		.52

The correlation coefficients presented in Table I become all the more interesting when it is noted that the correlations for certain of the general qualities seem in general to vary consistently according to the nature of the teacher-subject combinations. Conspicuous examples of high correlations appear with reference to certain qualities when the ratings of teachers of similar subjects are compared. Conspicuous examples of low correlations appear when the ratings of those who teach subjects obviously dissimilar in organization, content, and method are compared. Noting this, the writer was led to devise a scheme for a more minute analysis. It was assumed that certain of the general qualities such as ability to organize, and accuracy are more likely to vary in accordance with the changes in the subject back-

*Key for interpreting symbols designating teachers:
[1]The first letter in the combination indicates sex of rater, M-man; W-woman.
[2]The second letter or group of letters indicates subject taught by teacher, as follows: E-English; HE-Home Economics; ST-stenography-typewriting; M-mathematics (general); A-algebra; G-geometry; P-physics; C-chemistry; B-biology; Z-zoology; D-mechanical drawing; SC-industrial science; L-Latin; F-French; Ac-accounting; H-History; PS-public speaking.
[3]The small figure to the right of letters indicates the number assigned to the teacher in his or her department.

grounds than are other qualities which are more general in character, such as punctuality and social qualities. Combinations were made of subjects which appear to be similar. Correlations between the ratings of teachers of these subjects were compared with correlations between the ratings of those teaching subjects estimated by the writer as dissimilar.

Table II presents estimates made by the writer as to similarity and dissimilarity of separate pairs of subjects. It must be held in mind that these estimates are wholly arbitrary. No attempt was made, objectively, to analyze the subjects involved. It would seem, however, that the assumptions are justified.

TABLE II.

Estimated Similarity and Dissimilarity of Subject Combinations.

Similar or Partially Similar Subject Combinations.	
Mathematics	Physics
Stenography	Stenography
*English	Home Economics
*Public Speaking	History
*English	Zoology
Physics	Chemistry
Mechanical Dr.	Geometry

Dissimilar Subject Combinations.	
Biology	Latin
English	General Mathematics
English	Geometry
Physics	French
English	Algebra
Physics	Public Speaking
Latin	General Mathematics
Home Economics	General Mathematics
Accounting	History
English	Industrial Science
English	Mechanical Drawing
Stenography	History

The meaning of the terms "similar" and "dissimilar" as used in Table II is as follows: The word "similar" is applied to subjects which are estimated as having a

*The starred combinations of subjects are held to be partially similar for the following reasons:

(1) English—Home Economics.—Classes place considerable emphasis on the writing of acceptable themes on such subjects as, "Modern Appliances in the Home", "Laundering", etc.

(2) Public Speaking—History.—Fluency in expression is important in history recitation. Both subjects deal with materials of an abstract nature. Memory work is important in both.

(3) English—Zoology.—The biological sciences lay a great deal of stress on acceptable note books which are quite influential in helping to determine student's grade. The standards of organization, well expressed ideas, and neatness are common with English.

great deal in common, while "dissimilar" refers to subjects which are considered as having very little in common.

Percentages representing the total number of correlations for each general quality for both similar and dissimilar subject combinations are given in Table III. Percentages are distributed according to quartiles. For example: "38%" is opposite "application" in the column headed "similar". This means that thirty-eight percent of the total number of correlations between ratings of teachers of similar subjects, for the general quality "application", are in the highest quartile of the distribution for this quality. "15%" in the column headed "dissimilar" means that fifteen percent of the total number of correlations between ratings of teachers of dissimilar subjects are in the highest quartile of the distribution for the quality application.

TABLE III.

Percentages of Correlations Distributed by Quartiles.

	Highest Quartile		Second Quartile		Third Quartile		Fourth Quartile	
	Similar	Dissimilar	Similar	Dissimilar	Similar	Dissimilar	Similar	Dissimilar
Application	38%	15%	19%	31%	31%	23%	12%	31%
Ability to Organize	36%	18%	36%	18%	29%	23%	00%	41%
Punctuality	21%	27%	36%	18%	36%	18%	07%	36%
Accuracy	38%	18%	31%	18%	19%	27%	13%	36%
Aggressiveness	37%	17%	37%	17%	13%	33%	13%	33%
Social Qualities	10%	33%	50%	11%	20%	28%	20%	28%

Data of Table III are presented in graphic form in Figures 1 and 2. Figure 1 shows the distribution of correlations between the rating by teachers of similar subjects, and Figure 2 that of correlations between the ratings by teachers of dissimilar subjects. From the highest to the lowest quartile the curves for the general qualities, ability to organize, accuracy, and aggressiveness, show a decided slope from the upper toward the lower end of the scale in Figure 1, and a decided rise from the lower toward the upper end of the range in Figure 2. The curves for the qualities, application,

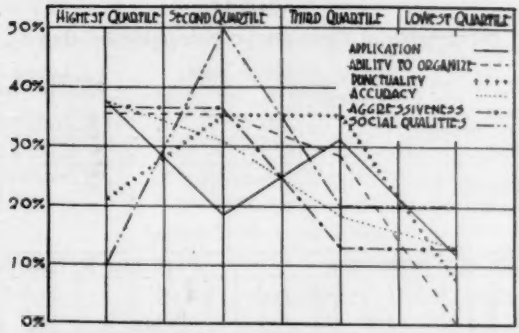


Fig. 1. Distribution percentages of correlations between ratings by pairs of teachers of similar subjects.

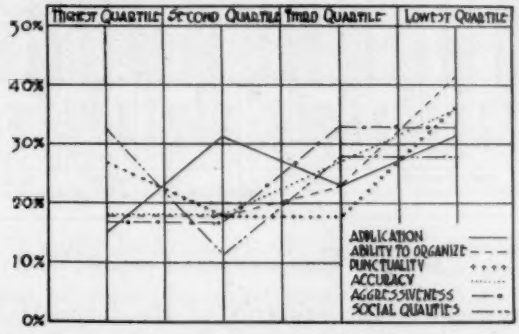


Fig. 2. Distribution percentages of correlations between ratings by pairs of teachers of dissimilar subjects.

punctuality, and social qualities slope and rise slightly in the direction of the others. This tendency is so slight, however, that considered along with the irregularity of the three curves, it seems inconsequential.

In consideration of the comparatively small number of correlations, and the small margin of difference in the size of correlations near the quartile division points, it seems advisable to supplement Table III and Figures 1 and 2 with a distribution of the total number of correlations by halves. Table IV shows the same data as are given in Table III. Data of Table IV are presented graphically in Fig. 3.

TABLE IV.

Percentages of Correlations Distributed by Halves.

	Upper Half		Lower Half	
	Similar	Dissimilar	Similar	Dissimilar
Application	57%	46%	43%	54%
Ability to Organize	71%	36%	29%	64%
Punctuality	57%	45%	43%	54%
Accuracy	68%	36%	32%	63%
Aggressiveness	74%	34%	26%	66%
Social qualities	60%	44%	40%	56%

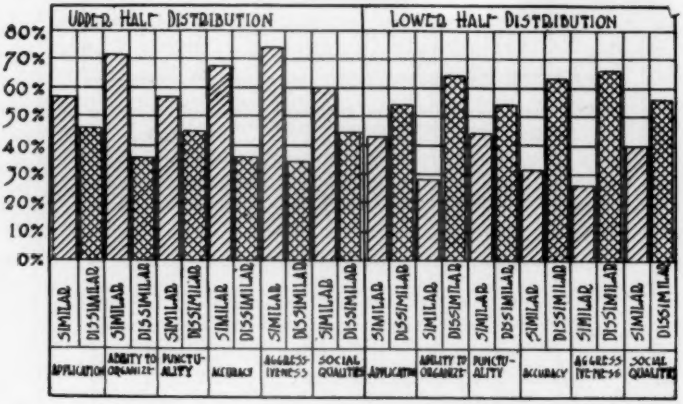


Fig. 3. Distribution percentages of correlations between ratings by pairs of teachers of similar and dissimilar subjects.

Approximately three-fourths of the correlations between ratings by teachers of similar subjects for each of the qualtities, accuracy, ability to organize, and aggressiveness fall within the upper half of the distribution. A bare majority of correlations between like ratings for the remainder of the general qualities are also within the upper half of the distributions.

Table V presents the highest three and lowest three correlations for the qualities, aggressiveness, ability to organize, and accuracy, the qualities, correlations for which show relatively greater variation according to the subject backgrounds of the teachers rating.

TABLE V.

Highest Three and Lowest Three Correlations in Three Qualities.

Aggressiveness	Ability to Organize	Accuracy
(Highest three correlations.)		
Math.Physics ... .86	Math.-Physics .... .78	Stenog-Stenog. .. .89
Public Speaking-History ..... .73	History-Public Speaking ..... .70	Mechanical Drawing-Math. ..... .82
Physics-Public Speaking ..... .69	English-Home Economics ..... .69	Math.-Physics ... .78
(Lowest three correlations.)		
Math.-Latin ...—.23	History-Stenog. ... .14	Stenography-History ..... .22
Stenography-History ..... .00	English-Industrial Science ..... .24	Mathematics-Home Econ.... .30
English-Mechanical Drawing ..... .16	English-Mechanical drawing .... .26	English-Mechanical Drawing .. .41

The highest three correlations for each quality, with the single exception of that for physics and public speaking under aggressiveness, are between the ratings of teachers of similar subjects. The lowest three correlations for each quality are between the ratings of teachers of dissimilar subjects. It may be noted, furthermore, that all the highest three correlations for accuracy are between ratings of teachers of strictly technical subjects.

GENERAL SUMMARY

Correlations between the ratings of the several pairs of teachers show a wide variation. The wide variability is doubtless caused by many factors some of which, only, are apparent. The variation is greater for the ratings by certain pairs of teachers than for the ratings by other pairs of teachers. The variation is greater with respect to certain general qualities than with respect to others.

Correlations between the ratings by teachers of similar subjects are noticeably higher for the general qualities, ability to organize, accuracy, and aggressiveness; corresponding correlations are slightly higher for the general qualities, application, punctuality, and social qualities.

Correlations between ratings by teachers of dissimilar subjects are relatively lower for all the general qualities than are correlations between ratings by teachers of similar subjects. The correlations are decidedly lower for the qualities, aggressiveness, accuracy, and ability to organize.

CONCLUSIONS

No sweeping conclusions should be reached on the basis of data presented in the present study. The number of correlations dealt with is limited. Rating results treated are the experiences of only one semester. These and other limitations should be held in mind as findings are evaluated.

It seems clear that the ratings on certain general qualities vary greatly according to the different interpretations given the quality by teachers possessing different subject backgrounds. If this is true, it is dangerous to average ratings of a student on any quality which are made by a heterogeneous group of teachers. Averages thus made and handed down will conceal many phases of the student's personality. It would seem that such averages can not be intelligently interpreted. However justified it may be to use composite marks and estimates in industrial personnel procedure, it is extremely questionable to borrow this policy and to apply it in school practice.

A record of careful ratings of the student by different teachers, which extends over a considerable period of time, should be looked upon as a wealth of information by the educational or vocational counsellor. In such a record will be found hints as to proper avenues for further investigation and study. Estimated weakness in any general quality in one department necessarily does not imply weakness in the same quality in a different department. The present study would seem to point the way to an informal and thorough consideration of each and every separate opinion which has been submitted by a careful and competent teacher. The personnel office must not choose the easiest way out, in its recording and interpreting of ratings.

PAPERS ON HIGH SCHOOL SCIENCE

SCIENCE CLUBS IN THE HIGH SCHOOL

GUY N. SMITH, HIGH SCHOOL, ROCKFORD

That there has been a great change in our schools in the last few years regarding science, no one will question. It was not many years ago that the student first came in contact with scientific knowledge in his college course. Today all this is changed. The science course has stepped down into the high school, and as General Science, we may say, not only stepped down into the high school, but into the upper grades of the elementary school. As our modern civilization reflects more and more the results of scientific thinking and investigation, must not our school program give a larger place to proper scientific work? The student is not educated who goes through life unmindful of those things of the world which are about him every day. If the school can encourage the child in his native curiosity—about the earth, the trees, the rocks, the sky,—all these things, and also man-made machinery, it has done something for the individual. When a better understanding of some of these things is gained, life will mean more. As a means to this end, has the science club a legitimate place in our high school life, and can it be made a means of service to the students? We wish to report on what the present situation in our high school seems to be, to offer a few suggestions as to what may be done, and to give illustrations of what in some instances has actually been or is being accomplished through such club organizations.

In order to gain some idea as to how many high schools might have a science club in their school activities a small survey was made. The unit taken for this survey was the Northern Illinois State Teachers Association. This association includes nine counties of northern Illinois and is represented by fifty-seven high schools. While it is known that this is a small unit and the results obtained may not be very significant, yet on the other hand, the data gathered may be typical of any or all such school units. From the fifty-seven questionaires sent out, forty-three were returned. These replies came from schools varying in size from twenty-three pupils to over twenty-three hundred pupils. Several of the schools

were community high schools—some were township. From the forty-three schools represented only six reported as having science clubs, although all were giving some work in science of one kind or another. In terms of percent this would show that about 13.7% of the schools making a reply had a science club, but of the total number of schools in the unit, only 10.5% reported a club.

Only two schools submitted reasons for not having a science club. The principal of a school of seventy pupils, sixty-five of whom studied science, gave as a reason the fact that since most of the students came from rural districts, it was thought best to limit the number of outside activities. The head of the science department from a school of eight hundred pupils with three hundred enrolled in science classes expressed disfavor for science clubs, as experience had shown that the chief advantage was mostly advertisement, and as far as actual work accomplished it could be done just as well—if not better —in the classroom where all could get the benefit, rather than in a club where the chief good would come to only a chosen few.

The type of club and the work attempted in the schools reporting organizations showed quite a variation. One school has a Radio Club of twenty-five boys; another the Home Economics Club for girls, and the Agriculture Club for boys. Two schools report the Science Club with no restriction as to membership. A Junior High School has the Nature Study Club for both boys and girls. The largest school in the unit reports five clubs, each one representing in a large degree a specific type of work.

Can a program for science clubs be outlined that will justify their position in a high school? Is it too much to ask that the work be along both social and educational lines? Is there a work of value to be done in a club that cannot be accomplished in a science class? The schools of today must send out boys and girls trained to be leaders in the world of tomorrow. The meetings of the club give the students an opportunity to meet and get acquainted with one another. This is especially important in a large school. It is a help to school spirit to have the students acquainted with each other. The officers have certain duties to perform. They will

realize that they must do these things or the whole organization will suffer. The fellow students have elected them because they believe in them. They feel an impetus to make good. The programs for the most part are to be given by the students. Here the students will receive training along various lines. If they are to appear on the program they must be prepared and ready to do their part and appear well before their associates. They will learn to share responsibility, to do their part of the job, carry through the project they have started, or think through a new one. Who can say that such work is not worth while? The work will not always be the same. Now and then an outside speaker of note may be called in. This will tend to give the students greater vision. The programs must vary to keep up interest. But with wise and careful faculty supervision this can be done and each member may derive the maximum of good.

To leave the field of speculation, let us see what one school has done and is doing with her science clubs. Rockford High School, with an enrollment of 2370 students, has five distinct clubs in the science department. Four of these organizations do specialized work; one does work of a general character.

The Wireless Club has been in existence since 1907. This club is for boys only. Its meetings are held each week on Monday afternoon and on Friday evening. The programs are always helpful and interesting. At the Monday meetings topics of current interest and importance in this field are considered. This group has recently constructed a 50-watt transmitting set, and this particular phase of the work is taken up at the evening meeting. The treasury of the organization is increased by building receiving sets which have been sold. Here we see a coordination with the work in the wood shop. Problems regarding school life are part of the work—at present the matter of placing amplifiers in the school auditorium is a project being considered.

The Biology Club is another of the older clubs. Both boys and girls may join. At present there is a membership of nearly sixty-five students. The programs consist of talks, discussions, papers, also music and games.

When weather permits field trips are made. A picnic is an annual event. The individual members work out projects for the school and even the community—trees in the yards of the city's public schools are classified and labeled—these and numerous other similar projects carried through every year make the work of the club decidedly worth while. From the membership of this club have gone several young men and women who today are out in the world doing splendid and creditable work along biological lines. Who dare gainsay but that it was at the meetings of this organization, or while working on a project for presentation before the group, that the student caught the vision and was inspired to go on in the work? The club as a unit is buying two seats in the new Stadium. From the field trips and excursions many snapshots are secured for the school Annual. These things all add interest and make for the proper school spirit.

The Agriculture Club is only for the boys taking agriculture. This club promotes the interests of agriculture and is both a social and an educational organization. Officers are elected by the members. Meetings are held every two weeks and varied programs are presented. Agricultural speakers of note frequently address the club. The boys have debates; rural plays are sometimes given. In the Fall and Spring the meetings are often held at the farm home of one of the members. A Father and Son banquet given by the boys to their fathers is an annual event. Here the club is doing a real service in linking the school with the home and the life of the community. Enough money is raised by the organization each year to defray all expenses of the Stock Judging Teams.

The Camera Club is open to all students interested in photography. From an educational viewpoint the work consists of study of the chemistry of photography; in the taking and enlarging of pictures; colored photography, and also the composition of pictures from the artistic side. Hikes and feeds furnish the social side of the work.

The youngest organization in the school is the Pasteur Club. This organization allows only Freshmen boys and

girls in its membership. The work attempted here is purely in the field of general science. The students furnish the programs of experiments, papers, and discussions, music and games. On hikes and field trips those with cameras often take pictures illustrative of some part of the class room work. These pictures are enlarged and used in the class room.

Scientific plays are written and given by the students. Outside speakers are at times asked to address the club on some interesting topic. This group has a more general type of work since the student in his second year is eligible to the other clubs which have a more specific work. By means of this club the young student is given a new interest in his science work and in his school life in general. He has an opportunity to receive training as he comes in contact with fellow students, and in the second year is ready to continue his work in one of the other organizations of the school.

It seems to be quite evident that there is a real value in science clubs in the high school. There is a supplementary work which can be done in the club which cannot possibly be done in the class room. The work of the club is not only valuable from an educational viewpoint but it has a real social value as well. The per cent of schools using the science clubs as a means for more effective work in this field is much too small. By continued effort along this line the work of the science class room can be made much more effective and its value increased both for the student himself and for the community.

MAKING THE LABORATORY THE BASIS OF HIGH SCHOOL SCIENCE.

H. H. Radcliffe, High School, Decatur

I was interested during the early days of the world war in a magazine article concerning the boyhood of a Cleveland, Ohio, man, whose name I have forgotten, who worked his way to an enviable place, not only in that, but also in other communities. At sixteen, as I remember the story, he was left as the sole support of his mother. Work just at that time was hard to find, but some of the friends of the family interested themselves in his situation and he was finally given a place as night watchman in the local gas plant. It was described as a position of small pay and less work, but an opportunity to "keep the wolf from the door."

When he reported for work he was shown the machinery that he was to watch and informed that his predecessors used to sleep most of the night as there would be noise enough, if anything went wrong, to waken him in plenty of time to prevent any injury to the plant. But this boy preferred not to sleep. He wanted to know the how and why of what was before him. He concluded the best way to find out was to study the thing itself. This he proceeded to do. When the day-man came to waken him he found him not asleep but closely observing some of the appliances. This he continued to do each night.

When the young man had learned what he could first hand, he took part of the daytime allotted to sleep to see what he could find in the city library on his subject. By getting what he could first hand, then reading what others had written of their observations, he soon won promotion. As he was given greater responsibility he advanced in knowledge of the plant. It was not long till he saw places where he could reduce the cost of production. Not only this, but he also found sale for by-products. In this way the plant was put on a firmer financial basis. It was not many years till he was in demand to put on their feet similar plants in other places.

He gave as his key-note—and this is the part that particularly interested me—"Learn first all you can from the objects themselves; then find what others have said about them; finally, with their viewpoint in mind, go back to the object for confirmation."

At the time I read this article I was teaching, among other science subjects, a class of freshmen in Botany. I had been studying how I might get them interested in the local flora. I determined to have them examine such representatives of the different groups as they could find, but in my order of selection. The complaints on their part toward the end of the semester were not encouraging to me. But early in the next semester they were led to see the development and evolution of types by such questions as: After studying these two types, what do you find in the pteridophytes that you did not find in the bryophytes? As individuals of different types were studied in this way their interest grew rapidly and by the end of the year, almost to a person, they wanted more science.

When we were called upon to close shop on Mondays in order to save coal, I was asked to conduct a class of adults, who were working on other days, on the gasoline engine. A local firm sent an engine to the room where the class was conducted. We examined that engine and many were the questions asked. Many expressed regret when the time came to close. I think I learned as much as any of them.

Three or four years ago among five or six classes in Chemistry I made the manual (Smith's) the basis of the work. In the elections for the next semester the class which was to follow this method was filled to overflowing before the others were full.

It is interesting to notice in this connection, the attitude of the War Department during the World War. To illustrate: One of our boys returned from the Great Lakes Training Station after the Armistice was signed and asked for credit in electricity for work he had done there. He presented his notebook for credit. Upon questioning him in regard to work in connection therewith, I learned that they were given a thorough practical training in wireless, sending and receiving, and then sent

east (this one to Harvard, I believe) for the theoretical side. I have read that colleges generally objected to the order of procedure (the farther east the more so) but the War Department came back with, "We must have doers."

Last year, during one six-week period of our school, I gave laboratory work first, followed by text assignment and discussion, to one group: while to another group an assignment was first made in the text, and the next day illustrative laboratory experiments worked out. During the next six-week period the order was reversed with each group. A summary of the grades of both sections convinced me that on the whole the Cleveland "Gas Doctor" was right. There were a few individuals who resented the order of procedure and asked me to tell them what to look for before they began the work. It is interesting to me to note that only a few days ago one of the girls said to me that she found the work on the auto engine so interesting and got so much out of it that she was going to put on some old clothes some day when she did not care if she got her hands smeared, and take their engine all apart. She is sister to the one who made so much objection the year before.

The following are my directions for the work on the automobile. The engine was supplied by a local dealer.

THE GASOLINE ENGINE

(Remember that other classes will work with this before you return; accordingly the small parts must be put in a box and labelled as they are removed. Put the bolts, screws, clamps, etc., that hold parts together, each in a box by itself and label clearly.)

Remove the head and the valve housing cover. Slowly turn the crankshaft till one piston is about one-fourth of the way down. Notice the position of each connecting rod, each valve and of each cam on the camshaft. Determine which cylinder is firing. Make a diagram of a section through all the cylinders and crankshaft showing each part in its present relative position. Superimpose upon this (preferably with another color) a section of the center of the valves and camshaft. By means

of arrows show the direction each movable part is about to take. Also state in what part of the cycle each cylinder is now.

Turn the crankshaft till you can see that one piston is as far down as it will go. Compute the volume of the cylinder above the piston and add the volume of the head-cavity. Assuming that the gas enters the cylinder when the piston is down at a pressure of one atmosphere and that none of the gas escapes, what will be the pressure when the piston is forced up as far as it will go? State the law involved. The difference in the positions of the pistons just indicated is the length of the stroke.

After the engine has been running for a time, the temperature is said to be about 600° F. When it is exploded the temperature is suddenly raised to 3000° F.; what would be the pressure then? What law is involved? State it. After allowing for the pressure necessary to compress the gas in another cylinder, and 10% of the remander for friction loss, what would be the total force on the piston head? What would be the available horsepower if the engine were making 1500 R. P. M.?

THE CARBURETOR ASSEMBLY

Study carefully the parts of a carburetor. Notice where the gasoline enters, where the air enters, where the valve for control is, and where the mixture leaves the carburetor. When you have mastered the relations of these carefully make a diagram to show the relative position of each and by means of arrows indicate the course of the air, of the gasoline and of the mixture. If there be a control for high speed, notice the mechanical device for such control. State all the physical principles involved in the carburetor.

I maintain that chemistry and physics are Nature Studies.

As I recall the life of this man and continue to study the minds of my pupils, I have been led to believe that a first hand study of the objects of nature, or of objects which illustrate the laws of nature, followed, not pre-

ceded, by a discussion of these laws will be the most thought-provoking method of procedure in high school science. It seems to me, above all else we want our pupils to THINK.

THE RELATION OF MENTAL IMAGERY TO MENTAL AGE

LESLIE L. HUNT, HIGH SCHOOL, GALESBURG

It is a matter of common knowledge that nearly every one at times draws various characters or pictures while the mind or consciousness is focused on other matters. From talking with several reliable persons immediately after they had made such markings, the writer is convinced that many times the individual is unaware that he or she has made the writings or markings in question. Upon this and other considerations, the writer believes such activities to be a type of subconscious behavior depending on or prompted by spontaneous imagery.

Galton and others have studied the phases of mental imagery that were under the control of the subject investigated. As a rule, the mental images in those cases were provoked after sustained effort. There have been several articles on the subject of spontaneous imagery and the accompanying delineations, but nearly all were confined to marks made by subjects while engaged in talking over the telephone. In turn, nearly every case investigated was that of an adult.

It is the purpose of this paper to deal with the imagery and attendant behavior of persons from six years of age upwards. Every effort consistent with accuracy has been made to eliminate all writings and drawings except those springing from conditions incident to mind wandering. The problem herein considered is this: Are the writings and drawings made during periods of mind wandering in any way correlated with the mental age or attained mental capacity of the person producing them?

As a means of attack, investigations were made by carefully recording all the characters and drawings found on the furniture, radiators and walls of schools and colleges. The space available to a student while in a position of relaxation is hereafter called a student-space. After making a very close study of over 1000 student-spaces, it became evident that any group of 250 student-spaces, taken at random, was thoroughly representative of a much larger number. This discovery was fortunate, as it rendered uniform investigations possible

in almost any system of city schools. Before tabulating, all communications, problems, puzzles, rebuses, evidences of unfair copying, etc., were eliminated. These obviously owed their origin to a state of consciousness. Detailed studies were made in coeducational colleges, high schools, a teachers' training school, primary schools and telephone booths. Some attention was given to foreign schools and an academy. By selecting a large number of student spaces in places occupied by individuals of different ages, the types of imagery most frequently associated with the respective ages were deduced.

In one college investigated, there were about 600 students. Nearly one-half were members of one or more secret societies not connected with the college. The initials of Greek letter organizations were very much in evidence on nearly every available student-space. Although there were about as many lodges represented in the student body as there were Greek letter organizations, not a single emblem nor initial could be attributed to the non college organizations in over 1000 student spaces that were examined. The admonitions to secrecy in some of the organizations could not be made to account for the absence of their emblems, since many of them carry on vigorous campaigns for members, and have public exhibitions of their work. Nor can the prevalence of the college organizations' symbols be explained on the ground that the student naturally writes or draws the ideations most intimately connected with the college. Athletics is one of the most absorbing activities in present educational life, yet the delineations pertaining to athletics including "pep meetings" in no case ranked above eleven in order of occurrence. Social organizations, and not beneficial or benevolent organizations, occupy the larger share of college students' mind wanderings. If names and initials be classed together, a close relation between the ego of the student and social activities may at once be discerned.

The data presented were checked with that found by examining a similar number of student spaces in two other colleges in Illinois, and with the limited amount of observations in certain class rooms of an eastern uni-

versity. The results in each case were consistent with those presented in the College Column of Table I, with the exception that three dimensional figures were more in evidence in the Eastern institution. Permission was obtained from a state normal institution to investigate the marks found in its student-spaces. The class rooms usually occupied by students of college grade, high school, and the various grades of the training schools yielded results that were in accord with the data obtained from other sources. Several high school class rooms and study halls were examined. A number of observations, each covering 250 student-spaces, when averaged gave the results tabulated in the High School Column of Table I. Considerable uncertainty surrounded the interpretations of the observations made in the academy. While the students were carrying regular secondary school subjects, they were, for the most part, much older than those found in high schools. The type of imagery evidenced was of a type more nearly like that of the colleges than that of the high schools. Whether this closer resemblance was due to association with college interests, or to the riper years of the student body cannot be said with certainty.

It has been the writer's privilege to examine the student-spaces in several schools in Bolivia and Peru. With the South American Student, the operations herein discussed do not seem to be so active on student-spaces but run rampant on the smooth exteriors of the buildings. These marks were undoubtedly influenced by attendant circumstances, and were therefore disregarded.

Several grade schools were investigated in the same manner as were the high schools and colleges. Telephone booths, frequented by adults, (particularly those where some comfort to the speaker is possible) were also closely examined. The results obtained were tabulated in their respective columns in Table I. All the data are analyzed in Table II.

It should be noted that the imagery portrayed follows closely the natural interests and aptitudes found in the various stages of childhood and adolescence. Judgment should temper the conclusions drawn on individual cases unless there is abundant and reliable data at hand. That

is to say, a child at the age of twelve, who absent-mindedly draws three dimensional figures or writes the names of various social organizations, does not necessarily evidence precocity, but if the child both draws three dimensional figures and writes social formula, the case is undoubtedly an unusual one. However, if an upper classman in high school or a college student persists in writing or drawing obscene words or characters, the writer seriously questions if the individual has really emerged mentally from the state of preadolescence.

The writer has found it very helpful to examine the writing and marks in the books of students who are deficient in their school work. The translation of these marks into mental ages, by means of Tables I & II, has in a large number of cases been a valuable check on the mentality tests that are now in use.

Grateful acknowledgement is made to Professor S. P. Williams, Illinois Wesleyan University, for his criticisms during the organization of this paper; and to Superintendent C. F. Miller, and Principal O. O. Young of the Galesburg Schools, for their encouragement and helpfulness during its preparation.

TABLE I.

The Relation of Mental Imagery to Mental Age.

Types of Imagery as indicated by the delineations on 250 student-spaces or equal.	WHERE FOUND													
	College		High Schools		Grades 1 and 2		Grades 3 and 4		Grades 5 and 6		Grades 7 and 8		Tel. Booth	
	The first number is the times that the characters occurred; the second number is the rank.													
Addresses	21	11	4	16	0		0		4	9	3	12	5	8
Animals, real	0		2	17	37	1	30	1	37	1	12	6	0	
Animals, grotesque	4	17	20	9	0		0		9	6	58	3	6	7
Athletic	7	14	4	16	0		0		0		4	11	2	11
Bodies, human	22	10	5	15	0		0		0		2	13	4	8
Dolls	1	18	0		0		20	2	24	2	12	6	2	11
Faces, men	58	5	50	3	0		0		2	11	6	9	6	7
Faces, women	42	8	25	8	1	5	0		1	12	7	8	3	10
Faculty, names of	14	12	6	14	0		0		0		0		....	..
Figures, plane	7	14	33	5	2	4	5	4	0		4	11	5	8
Figures, solid	56	6	0		0		0		0		2	13	9	5
Frats. and Clubs	353	1	15	11	0		0		0		1	14	0	
Hearts	45	7	28	7	0		0		6	8	2	13	7	6
Houses	0		0		35	2	10	3	4	9	0		0	
Initials	175	2	120	1	0		3	6	20	3	66	2	141	2
Marks, irregular	98	4	15	11	6	3	2	7	3	10	5	10	176	1
Names, personal	119	3	80	2	0		3	6	13	4	24	4	88	3
Obscenity	0		8	13	0		1	8	12	5	117	1	3	10
Seascapes	7	14	0		0		0		0		0		2	11
Skeletons	4	17	0		0		0		3	10	2	13	0	
Words, gibberish	8	13	0		0		1	8	0		0		4	9
Words, various	27	9	32	6	0		4	5	8	7	14	4	12	4
Years past	6	15	12	12	0		1	8	2	11	10	7	3	10
Years, class	5	16	46	4	0		0		0		0		....	..
Total Marks	107	2	505		81		80		139		351		478	

TABLE II.

Grades	Usual ages in Schools Investigated	Type of Imagery in order of rank.	Characteristics.
1 and 2	6 to 8	Animals, real; Houses; Marks, irregular; Figures, plane; Faces, women.	Imitation. The irregular marks are probably due to lack of coordination. The faces are likely of the teacher.
3 and 4	8 to 10	Animals, real; Dolls; Houses; Figures, plane; Words, various.	Continuation of imitation. The appearance of dolls is obvious. The words were chiefly nouns.
5 and 6	10 to 12	Animals, real; Dolls; Initials; Names, personal; Obscenity and grotesqueness.	Animals and dolls reflect the respective tastes of boys and girls. Initials are studied about this time. The obscene and the grotesque have an appeal in early preadolescence which continues with the advance of adolescence. Verbs now lead the word list.
7 and 8	11 to 14	Obscenity, initials, grotesque animals (winged mammals, six legged creatures, etc.); Personal names and various words.	
High School	14 to 19	Initials, names, men's faces, class-years, plane figures.	Initials and names found mostly in pairs not necessarily with the opposite sex. The men's faces were serious efforts. Note the "pre-social" age manifested by the class years and initials in pairs.
College	17 to 23	Social activities, ego abstract lines, men's faces, three dimensional figures.	The social age. The irregular lines probably indicate a primitive philosophy. Note that three dimensional figures do not appear before college age.
Telephone booths	Adults	Largely abstractions and three dimensional figures.	Ability to think in the abstract.

BIRD STUDY IN HIGH SCHOOL BIOLOGY

JEROME ISENBARGER, CRANE JUNIOR COLLEGE, CHICAGO

There is no subject which is more worth while in high school biology from the esthetic side or from the point of view of science and pure natural history than the study of birds. The living bird may be studied in its own habitat, free and happy and engaged in its natural activities. The field study of birds arouses interests which are abiding. Aside from the fact that bird study provides for a worthy use of leisure time in the open air, it also shows the relation of birds to man's welfare and stresses importance of protection and encouragement. It is important for everyone to know that with a sufficient bird population, the greater part of the loss of $1,049,500,000 each year due to insects could be saved to the people of the country.

Field work on birds should extend throughout the year along with observations on insects, trees, fungi, weeds, and flowers. The study may assume the form of a survey of a suitable selected plot. In the country districts an ideal site could include the orchard and home lot. Location in the city is no excuse for omitting this essential part of the biology course. The nature of the work must be varied to meet the conditions. I have conducted field work from five different schools in Chicago, three of which were in the congested districts and I have found plenty of suitable spots easily accessible. The limited scope of this paper will not permit a detailed outline of the different types of field work which may be carried on in any given plot. One main line of investigation might be to determine whether there are enough birds in the area to hold the insects in check. This study would lead to the problem of determining what special features attract the birds to nest on the plot. The question, "Why is the bird here", calls for much clear observation. It is equally important to study the elements which account for a scarcity of bird life. The pupil must determine what necessities are absent. From these considerations it is only a step to the problem of determining what may be done to attract the birds to any given location.

Other lines of bird work that may be taken up relate to the destruction of weed seeds and to the control of rodents. The problem will involve a study of bird migration and means of providing for the winter birds so that they may be attracted within easy range of observation.

The spring migration calls for a study over a wider field with the emphasis on identification and related details. The opportunities offered for bird study in Chicago and in its immediate environs is a source of wonder. We have the parks, open spaces along boulevards, several wooded tracts and forest preserves along the river, all within the city limits. On the north side, we have been allowed access to Rose Hill Cemetery, a veritable bird paradise during the spring migration. Here may be found pied billed grebe, great blue heron, little blue heron, various species of ducks, loon, coot, thrushes, whippoorwill, barnswallow, chimney swift and a great list of others. Wild mallard ducks rear their young on the banks of the lagoons. In the back yards in the residence districts, where there is a considerable growth of shrubbery, may be found, especially during the migrating season, many different species. In our own back yard we have had such visitors as chewink, different thrushes, white-throated sparrow, brown thrasher, several species of warblers, scarlet tanager, catbird, cedar waxwing, Bohemian waxwing and many others.

With all of these opportunities for study, I felt justified, while teaching that work in the Senn High School, in requiring every member of the classes to know at least twenty-five birds. Most of the pupils learned to know many more than that number. As I remember, the greatest number to the credit of any one pupil was 150 different species. The greatest number of different species for all members of the classes for any one season was 250. Of course there were mistakes and some dishonesty, but experience in checking up reports enables a teacher to reduce dishonesty to a minimum which is almost negligible. Various contests add to the interest in this work. Trips are taken after school hours and before school hours by the different classes accompanied by the teacher, but after the work is well started, the best work is done by the pupils themselves, either individually

alone, or in small groups. I remember one pupil who was severely reprimanded by his parents when he returned home from a bird trip on a Saturday evening as late as nine o'clock. By Sunday morning he had the enthusiasm of the whole family aroused to the extent that they consented to go with him for an all-day trip on Sunday.

For this work, the pupil should have a pair of field glasses (cheap ones will answer), a note book and a bird guide such as Reed's or Chapman's. Several laboratory copies of Chapman's "Birds of the Eastern United States" should be available.

I have seen no better treatment of general methods of bird study than that found in Hodge and Dawson's "Civic Biology." Hodge's "Nature Study and Life" is also suggestive. Hornady's "Our Vanishing Wild Life" is good to help give a background for this and similar studies on conservation of our wild life.

In order to make any kind of a study of the economic relations of birds to man, we must know birds. Being able to identify the birds, to name them, is not enough. The pupil should have some knowledge of scientific classification. The laboratory should have mounted bird skins representing all of the orders of local importance and all of the common families of the perching birds. The different external characters which are used in identification are characters which are adaptations to the environment, so that important biological principles are stressed in such a way as to make permanent impressions. An excellent aid in the class work in connection with bird study is the stereopticon lantern. Slides made from photographs of the living birds are available, which offer studies in color, habits and habitats of birds which aid in preparing for the field work. Other slides which show diagrams giving a graphic representation of the economic importance of different species help in fixing the importance of this relation.

Most of the success or failure of bird study in high school classes depends upon the teacher. He must develop an enthusiasm for the work that is contagious. He must realize the social importance of the information

and training that bird study gives and attack the problems as a civic duty. The conservation of our wild bird life is a national, state and community problem and must depend upon each citizen knowing the different species and actually doing his part.

ONE INFLUENCE OF OUT-OF-SCHOOL ACTIVITIES IN DETERMINING THE HIGH-SCHOOL PHYSICS CURRICULUM

M. E. Herriott, Associate, Bureau of Educational Research, University of Illinois

Those of us who are in the field of education, both as practical and as theoretical school men and women, are constantly giving the major portion of our attention to one particular phase or another of our work. As the psychologist would put it, some one aspect occupies the focus of attention and the other phases are peripheral. As we think back only a few years, we see motivation, problem-project and testing, each taking the foreground in turn. And I believe that I can see the method or technique aspect of teaching looming before us as the center of attention only a few years hence. But just now, we are in the throes, as it were, of curriculum construction and course-of-study writing.

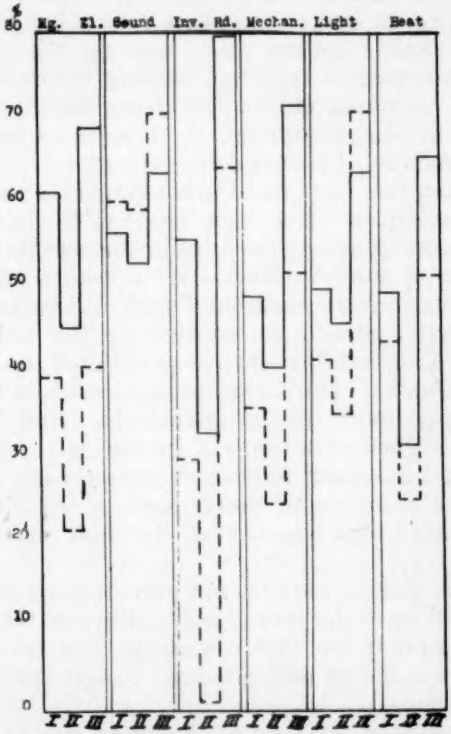
It was ten years ago that Parker stated the four fundamental principles which have been quite generally accepted as the guiding principles in the selecting and arrangement of subject-matter. We are all familiar with them so that a mere mention of each will suffice. First, subject-matter should be selected by the criterion of social need. Second, it should be selected on the basis of relative value. Third, subject-matter should be organized in large units treated intensively. And fourth, it should be organized in terms of the learner.

In what I am about to present to you, I am applying, chiefly, the principle of social need to the high-school physics curriculum, insofar as the data collected will permit.

The time allowed me does not permit of my going into great detail as to the source and validity of the original data. I can only ask that you accept them as valid for the purposes of this talk, although I shall briefly sketch what was done.

My purpose at the time of the study was to find out the extent to which the principles and elements of high-school physics enter into the everyday lives of ordinary people. So I presented a list of 576 activities to a group

of over one hundred individuals, including boys and girls of high-school age and men and women from 37 occupations. All of these 576 activities involved rather definitely ascertainable principles and elements of physics. They included things which people generally do for themselves, such as "Replace burned-out fuses"; things which they often have others do for them, as "Take pictures with a camera of special lens"; and things about which people think, as "Wonder what makes one 'hear the ocean' in a sea shell." Each person indicated the extent to which these activities entered into his life during the past year.



EXTENT, EXPRESSED IN PER CENTS, TO WHICH ACTIVITIES OF THREE TYPES INVOLVING PRINCIPLES OF PHYSICS ENTERED INTO THE LIVES OF PEOPLE.

Boys —— GRAPH 1. Girls – –

It is on the basis of these data that I arrived at the conclusions which I shall present.

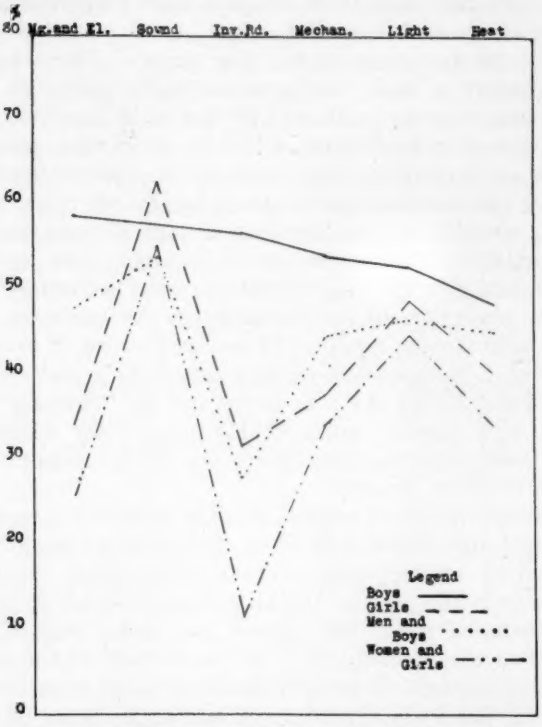
Now, let us return to the first graph. Here we find the answers of only the boys and girls pictured. The boys' interests are indicated by the solid line, the girls' by the broken line. The extent to which the activities involving principles from each of the large topics of physics entered into their lives is indicated in per cents. In the graph, columns numbered with Roman numeral I record the extent to which each topic, such as magnetism and electricity, is involved in the activities which people generally do for themselves; the columns numbered with Roman numeral II record the extent to which each topic is involved in the activities which people often have others do for them; and the columns numbered with Roman numeral III record the extent to which each topic is involved in the things about which people think or wonder.

It should be noted especially that, with the exceptions of sound and light, the boys are always much more affected by physics than are the girls. Note the large per cents in the case of thinking activities, which by the way, included much the longest list, being made up of 249 out of the 576 activities, or nearly half of the entire list. This thought or natural curiosity phase is one that is given all too little attention in our high-school physics courses.

Let us note the order of interest in this respect for boys. It is: Invisible Radiations, Mechanics, Magnetism and Electricity, Heat, Sound, Light. For girls it is: Light, Sound, Invisible Radiations, Heat, Mechanics, Magnetism and Electricty. Almost the reverse of the order for boys.

Now we shall turn to the second graph. Here we have the average of the three types of activities expressed in per cents again. The solid line is for boys, the broken line for girls, the dotted line for men and boys combined, and the dot-dash line for women and girls combined.

Note here particularly the dip in the topic of Invisible Radiations caused both by men and women, due no



EXTENT, EXPRESSED IN PER CENTS, TO WHICH ACTIVITIES INVOLVING PRINCIPLES OF PHYSICS ENTERED INTO THE LIVES OF PEOPLE.

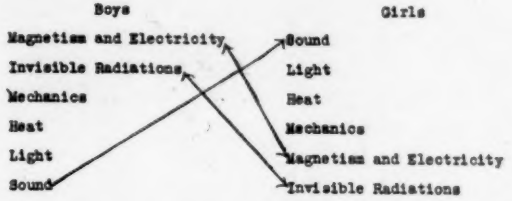
GRAPH 2.

doubt to the newness of radio, radium and the like, and to the intense interest of boys and girls in them but lack of interest on the part of older people who have not yet been reached, despite the enormous amount of publicity which has been given such subjects.

Now I have had to lead you very hurriedly through all of this, and I know that you have not traced every bit of evidence which has led me to the final conclusions, but I think that you have been given enough to see that there is some little foundation for the conclusions which I am about to present. You have seen that there are great variations in the extent to which the various topics of physics enter into the activities of people, that there

are wide differences in the interests of boys and of girls, and that the extent to which people think about things that involve principles and elements of physics is very noticeable.

On the basis of the evidence presented, which is the most pertinent and significant, and on the basis of some other considerations which I have not the time to give you now, I would suggest the following order of large topics in a high-school physics course:



These are not to be taken as final conclusions, but this study does present some very definite data which point in this direction. Further, it presents at least one aspect of curriculum construction in physics which is worthy of a great deal of study by the physics teacher.

You will find a slightly different account of this same phase of the physics curriculum in School Science and Mathematics for June, 1924. The conclusions there also vary a little, but I believe that the conclusions given here are more nearly valid, inasmuch as the matter has been given more study since the writing of that article.

I might add that Chester J. Peters, Supervisor of Science Teaching in the University High School of the University of Missouri, is using the results of the investigation as a basis for further study in the actual teaching of physics. I hope to see some real results published in a year or two as a consequence of his work, results which will give material assistance to teachers of high-school physics, both in the way of a curriculum and in the technique of teaching.

CONSTITUTION AND BY-LAWS

CONSTITUTION AND BY-LAWS

Illinois State Academy of Science

CONSTITUTION.

ARTICLE I. NAME.

This Society shall be known as THE ILLINOIS STATE ACADEMY OF SCIENCE.

ARTICLE II. OBJECTS.

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

ARTICLE III. MEMBERS.

The membership of the Academy shall consist of two classes as follows: *National Members* and *Local Members*.

National Members shall be those who are members also of the American Association for the Advancement of Science. Each national member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of five dollars.

Local Members shall be those who are members of the local Academy only. Each local member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of one dollar.

Both national members and local members may be either *Life Members*, *Active Members*, or *Non-resident Members*.

Life Members shall be national or local members who have paid fees to the Academy to the amount of twenty dollars. Life members, if national members, shall pay an annual assessment of four dollars.

Active Members shall be national or local members who reside in the State of Illinois, and who have not paid as much as $20.00 in fees to the Academy.

Non-resident Members shall be active members or life members who have removed from the State of Illinois. Their duties and privileges shall be the same as active members except that they may not hold office.

Charter Members are those who attended the organization meeting in 1908, signed the constitution, and paid dues for that year.

For election to any class of membership, the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

ARTICLE IV. OFFICERS.

The officers of the Academy shall consist of a President, a 1st Vice-President, a Librarian, a Secretary, and a Treasurer. The Chief of the Division of State Museum of the Department of Registration and Education of the State Government shall be the Librarian of the Academy. These officers, except the Librarian, shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

A 2nd Vice-President, who may be a resident of the town in which the next annual meeting is to be held, may be appointed by the council each year when the next meeting place shall have been decided upon.

The above officers shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The Librarian shall have charge of all the books, collections, and material property belonging to the Academy.

ARTICLE V. COUNCIL.

The Council shall consist of the President, 1st and 2nd Vice-Presidents, Secretary, Treasurer, Librarian, the retiring president and his immediate predecessor. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

At the Annual Meetings the presiding officer of each of the affiliated scientific societies of the State shall meet with the Academy Council for the discussion of policies.

ARTICLE VI. STANDING COMMITTEES.

The Standing Committees of the Academy shall be a Committee on Publication, a Committee on Membership and a Committee on Affiliation and such other committees as the Academy shall from time to time deem desirable.

The Committee on Publication shall consist of the President, the Secretary and a third member chosen annually by the Academy.

The committees on Membership and Affiliation shall each consist of five members chosen annually by the Academy.

ARTICLE VII. MEETINGS.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council, and shall be called upon written request of twenty members.

ARTICLE VIII. PUBLICATIONS.

The regular publications of the Academy shall include the Transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current publications of the Academy.

ARTICLE IX. AFFILIATION.

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council, and may be ordered by a three-fourths vote of the members present at any regular meeting.

ARTICLE X. AMENDMENTS.

This constitution may be amended by a three-fourths vote of the membership present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS.

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of Special Committees.
7. Unfinished business

8. New business.
9. Election of officers.
10. Program.
Adjournment.

II. No meetings of the Academy shall be held without thirty days previous notice by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and the Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Librarian shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary. No paper shall be presented at any meeting, by any person other than the author, except on vote of the members present at such meeting.

IX. The Secretary and the Treasurer shall have their expenses paid from the Treasury of the Academy while attending council meetings and annual meetings. Other members of the council may have their expenses paid while attending meetings of the council, other than those in connection with annual meetings.

X. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

LIST OF MEMBERS

LIST OF MEMBERS

Note—The names of charter members are starred; names in black-faced type indicate membership in the American Association for the Advancement of Science.

LIFE MEMBERS.

*Andrews, C. W., LL. D., The John Crearar Library, Chicago, Ill. (Sci. Bibl.)
*Bain, Walter G., M. D., St. John's Hospital, Springfield, Ill. (Bacteriology.)
Barnes, R. M., LL. B., Lacon, Ill. (Zoology.)
Barnes, William, M. D., 320 Millikin Bldg., Decatur, Ill. (Lepidoptera.)
*Bartow, Edward, Ph. D., University of Iowa, Iowa City, Iowa.
Chamberlain, C. J., Ph. D., University of Chicago, Chicago, Ill. (Botany.)
Chamberlain, T. C., LL. D., University of Chicago, Chicago, Ill. (Geology.)
Cowles, H. C., Ph. D., University of Chicago, Chicago, Ill. (Botany.)
*Crew, Henry, Ph. D., Northwestern University, Evanston, Ill. (Physics.)
*Crook, A. R., Ph. D., Chief, State Museum, Springfield, Ill. (Geology.)
Deal, Don W., M. D., Leland Office Building, Springfield, Ill. (Medicine.)
Farrington, O. C., Ph. D., Field Museum, Chicago, Ill. (Minerology.)
Ferriss, J. H., Joliet, Ill. (Conchology.)
*Fischer, C. E. M., M. D., 25 E. Washington St., Chicago, Ill. (Medicine.)
*Forbes, S. A., LL. D., Chief, Natural History Survey, Urbana, Ill. (Zoology.)
Fuller, Geo. D., Ph. D., University of Chicago, Chicago, Ill. (Botany.)
*Gates, Frank C., Ph. D., State Agricultural College, Manhattan, Kansas. (Botany.)
Hagler, E. E., M. D., Capitol Ave. and Fourth St., Springfield, Ill. (Oculist.)
Hankinson, Thos. L., B. S., State Normal College, Ypsilanti, Mich. (Zoology.)
*Hessler, J. C., Ph. D., Knox College, Galesburg, Ill. (Chemistry.)
Hoskins, William, 111 W. Monroe St., Chicago, Ill. (Chemistry.)
Hunt, Robert L., Decatur, Ill. (Soils.)
Jordan, Edwin O., Ph. D., University of Chicago, Chicago, Ill. (Bacteriology.)
Kuntz, Jakob, Ph. D., University of Illinois, Urbana, Ill. (Physics.)
Latham, Vida A., M. D., D. D. S., 1644 Morse Ave., Chicago, Ill. (Microscopy.)
Lillie, F. R., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Marshall, Ruth, Ph. D., Rockford College, Rockford, Ill. (Zoology.)
Miller, G. A., Ph. D., University of Illinois, Urbana, Ill. (Mathematics.)
Moffatt, Mrs. Elizabeth M., Wheaton, Ill. (Zoology.)
Moffatt, Will S., M. D., 105 S. LaSalle St., Chicago, Ill. (Botany.)
Mohr, Louis, 349 W. Illinois St., Chicago, Ill.
*Noyes, William A., Ph. D., LL. D., University of Illinois, Urbana, Ill. (Chemistry.)
*Oglevee, C. S., Sc. D., Lincoln College, Lincoln, Ill. (Biology.)
O'Hara, Fred S., M. D., 509 E. N. Grand Ave., Springfield, Ill. (Medicine.)
Payne, Edward W., First State Trust & Savings Bank, Springfield, Ill. (Archeology.)
*Pepoon, H. S., M. D., Lake View High School, Chicago, Ill. (Zoology, Botany.)
Rentchler, Edna K., B. A., Peabody Normal College, Nashville, Tenn. (Biology.)
*Smith, Frank, M. A., University of Illinois, Urbana, Ill. (Zoology.)
*Smith, Isabel Seymour, M. S., Illinois College, Jacksonville, Ill. (Botany.)
Smith, L. H., Ph. D., University of Illinois, Urbana, Ill. (Plant Breeding.)
Stevenson, A. L., B. S., Field School, 7019 N. Ashland Ave., Chicago, Ill.
Stillhamer, A. G., 705 N. East St., Bloomington, Ill. (Physics.)
Sykes, Mabel, B. S., South Chicago High School, Chicago, Ill. (Geology.)
Trelease, William, LL. D., University of Illinois, Urbana, Ill. (Botany.)
Ward, Henry B., Ph. D., University of Illinois, Urbana, Ill. (Zoology.)
Washburn, E. W., Ph. D., National Research Council, Washington, D. C. (Chemistry.)
Weller, Annie L., Eastern Illinois State Teachers College, Charleston, Ill.
*Weller, Stuart, Ph. D., University of Chicago, Chicago, Ill. (Paleontology.)
Zeleny, Charles, Ph. D., University of Illinois, Urbana, Ill. (Experimental Zoology.)

ANNUAL MEMBERS.

Abbott, Howard C., Ph. D., University of South Dakota, Vermillion, South Dakota.
Abrams, Duff A., C. E., Lewis Institute, Chicago, Ill. (Structural Materials.)
Adams, L. A., 605 W. Indiana Ave., Urbana, Ill. (Zoology.)

Adler, Herman M., M. D., 721 S. Wood St., Chicago, Ill. (Medicine.)
Agersborg, H. P. K., Ph. D., James Millikin University, Decatur, Ill. (Zoology.)
Alexander, Alida, M. A., Illinois Woman's College, Jacksonville, Ill. (Botany.)
Alexander, C. P., Ph. D., Fernald Hall, Mass. Agri. College, Amherst, Mass. (Entomology.)
Alldredge, Samuel M., A. B., P. O. Box 682, Johnston City, Ill. (Chemistry.)
Allee, W. C., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Ames, E. S., Ph. D., University of Chicago, Chicago, Ill. (Psychology.)
Anderson, S. L., M. D., DeKalb, Ill. (Medicine.)
Andras, J. C., B. A., 540 S. Main St., Manchester, Ill. (Astronomy, Botany.)
Armstrong, Christie, A. B., Princeville, Ill. (Physiography.)
Ashman, George C., Ph. D., Bradley Institute, Peoria, Ill. (Chemistry.)
•**Atwell, Chas. B.,** Ph. M., Northwestern University, Evanston, Ill. (Botany.)
Augur, Allison W., M. A., 5528 Blackstone Ave., Chicago, Ill. (Physics.)
Bacon, Chas. Summer, Ph. D., M. D., 2333 Cleveland Ave., Chicago, Ill.
Bailey, Wm. M., M. S., 701 S. Poplar St., Carbondale, Ill. (Botany.)
Baird, S. H., 708 Woodland Ave., Springfield, Ill. (Chemistry.)
Baker, Frank C., University of Illinois, Urbana, Ill. (Zoology, Conchology.)
Balduf, W. V., Ph. D., University of Illinois, Urbana, Ill. (Entomology.)
Banck, Hans J. E., M. E., 1422 Dial Court, Springfield, Ill. (Engineering.)
Bangs, Edward H., 212 W. Washington St., Chicago, Ill. (Agriculture, Electricity.)
Barnes, Cecil, LL. B., M. A., 1522 1st National Bank Bldg., Chicago, Ill. (Physical Geography.)
Barwell, John Wm., Madison and Sands Sts., Waukegan, Ill. (Anthropology.)
Bastin, E. S., Ph. D., University of Chicago, Chicago, Ill. (Geology.)
Bayley, W. S., Ph. D., University of Illinois, Urbana, Ill. (Geology.)
Beal, James Hartley, Sc. D., 801 W. Nevada St., Urbana, Ill. (Pharmaceutical.)
Behre, Chas. H., Jr., University of Cincinnati, Cincinnati, Ohio.
Bengel, George A., 808 S. 4th. St., Springfield, Ill. (Engineering.)
Bentley, Madison, Ph. D., University of Illinois, Urbana, Ill. (Psychology.)
Benton, Curtis, B. A., Macomb, Ill., (Entomology.)
•**Betten, Cornelius,** Ph. D., Cornell University, Ithaca, N. Y. (Biology.)
Bevan, Arthur, Ph. D., University of Illinois, Urbana, Ill. (Geology.)
Bigger, J. H., B. S., 305 No. Prairie Ave., Jacksonville, Ill. (Entomology.)
Black, Arthur D., M. D., D. D. S., Northwestern University, Evanston, Ill. (Dentistry.)
Blackstock, Ira B., M. A., 213 E. Jefferson St., Springfield, Ill. (Agriculture.)
Blake, Anna M., B. S., 409 W. Willow St., Normal, Ill. (Botany, Physiology.)
Blake, Mrs. Tiffany, 25 East Walton Place, Chicago, Ill.
Bleininger, A. V., B. S., Care of Homer Laughlin China Co., Newell, W. Va. (Ceramics.)
Bohannan, F. C., B. S., Galesburg High School, Galesburg, Ill. (Geology, Geography.)
Bonnell, Clarence, Township High School, Harrisburg, Ill. (Biology.)
Boomer, S. E., M. A., 207 Harwood St., Carbondale, Ill. (Physics.)
Boot, G. W., M. D., 813 Sherman Ave., Evanston, Ill. (Medicine, Geology.)
Breed, Frederick S., Ph. D., 5476 University Ave., Chicago, Ill. (Education.)
Brennan, George A., 24 W. 110th Pl., Chicago, Ill. (Principal Van Vlissingen School.)
Bretz, J. Harlan, Ph. D., University of Chicago, Chicago, Ill. (Geology.)
Brink, Chester A., M. D., Apple River, Ill. (Medicine.)
Brokaw, Raymond V., M. D., 1001 S. Second St., Springfield, Ill. (Medicine.)
Brophy, Truman W., D. D. S., M. D., 81 E. Madison St. Chicago, Ill. (Medicine.)
Brown, Agnes, 1205 West State St., Rockford, Ill.
Brown, George A., 304 E. Walnut St., Bloomington, Ill. (Education.)
Brown, Howard C., B. S., 409 Hamilton St., Geneva, Ill. (Botany.)
Brown, Walter J., M. D., 151 N. Vermillion St., Danville, Ill. (Medicine.)
Browne, George M., 902 S. Normal St., Carbondale, Ill. (Chemistry.)
Buckingham, B. R., Ph. D., Director of Bureau of Educational Research, Ohio State University, Columbus, Ohio. (Education.)
Burmeister, Wm. H., M. D., 536 Deming Place, Chicago, Ill. (Exp. Medicine.)
Buswell, A. M., Chief, State Water Survey, University of Illinois, Urbana, Ill.
Buzzard, Robt. G., M. S., State Normal University, Normal, Ill. (Geography, Geology.)
Cahan, Alvin R., M. S., University of Illinois, Urbana, Ill. (Zoology.)
Caldwell, Delia, M. D., 590 W. Main St., Carbondale, Ill. (Medicine.)
Campbell, Ian, M. A., Louisiana State University, Baton Rouge, La. (Geology.)
Card, H. H., 6220 Freret St., New Orleans, La. (Botany.)
Carlson, A. J., Ph. D., University of Chicago, Chicago, Ill. (Physiology.)
Carlson, Fred, Ed. B., State Teachers College, DeKalb, Ill. (Geography.)
Carmen, Albert P., Ph. D., University of Illinois, Urbana, Ill. (Physics.)
•**Carpenter, Chas. K.,** D. D., 311 Park St., Elgin, Ill.

Causey, David, University of California, Berkeley, Cal. (Biology.)
Challis, Frank E., 121 N. Wabash Ave., Chicago, Ill. (Analin Dyes.)
Chandler, S. C., B. S., R. R. 5, Carbondale, Ill. (Entomology.)
*Child, C. M., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Christie, J. R., B. S., M. S., East Falls Church, Virginia. (Biology.)
Clark, Albert Henry, B. S., 701 W. Wood St., Chicago, Ill. (Chemistry.)
Clark, H. Walton, M. A., Steinhardt's Aquarium, Golden Gate Park, San Francisco, Cal. (Biology.)
*Clawson, A. B., B. A., Dept. of Agriculture, Washington, D. C. (Biology.)
Clement, John A., Ph. D., Northwestern University, Evanston, Ill. (Psychology, Education.)
Cletcher, J. O., M. D., 10 N. Main St., Tuscola, Ill. (Medicine.)
Clute, W. N., Editor "The American Botanist", Joliet, Ill. (Botany.)
Coffin, Fletcher B., Ph. D., Lake Forest, Ill. (Physical Chemistry.)
Coggeshall, Ruth, B. S., 3927 Hamlin Ave., Chicago, Ill. (Biology.)
Colby, Arthur Samuel, Ph. D., 105 H. F. Laboratory, University of Illinois, Urbana, Ill. (Pomology, Pathology.)
Colby, Chas. C., Ph. D., University of Chicago, Chicago, Ill. (Geography.)
Cole, Herman H., B. S., M. D., 517 E. Capitol Ave., Springfield, Ill. (Medicine.)
Colyer, F. H., M. S., State Normal University, Carbondale, Ill. (Geography.)
Combs, Ralph Marion, 411 E. Healey St., Champaign, Ill. (Biology.)
Compton, James S., Eureka College, Eureka, Ill.
Cone, Albert Benjamin, 5245 Magnolia Ave., Chicago, Ill. (Forestry, Microscopy.)
*Crandall, Chas. S., University of Illinois, Urbana, Ill. (Botany.)
Crathorne, A. R., Ph. D., University of Illinois, Urbana, Ill. (Mathematics.)
Creager, Gail, Ed. B., Pinckneyville, Ill. (Biology.)
Crocker, William, Ph. D., Care of J. M. Arthur Thompson Institute, Yonkers, N. Y. (Botany.)
Crosier, W. M., M. D., Alexis, Ill. (Medicine.)
Crowe, A. B., M. A., Eastern State Teachers College, Charleston, Ill. (Physics.)
Cullison, Aline, 1454 E. 68th St., Chicago, Ill.
Curran, Gordon C., B. S., 407 W. Illinois St., Urbana, Ill. (Botany.)
Darling, Elton R., Ph. D., 1345 West Macon Ave., Decatur, Ill.
Dart, Carlton R., 706 Greenleaf Ave., Wilmette, Ill.
Davenport, Eugene, LL. D., Woodland, Mich. (Agriculture.)
Davies, D. C., Director, Field Museum, Chicago, Ill.
*Davis, J. J., B. S., Purdue University, Lafayette, Ind. (Entomology.)
Deam, Hon. Chas. C., M. A., Bluffton, Ind. (Forestry, Flora.)
Dean, Ella R., B. Ed., 310 E. Elm St., Olney, Ill. (Chemistry.)
Deffenbaugh, R. A., B. S., 630 W. Edwards St., Springfield, Ill. (Physics.)
DeLee, Jos. B., M. D., M. A., 5028 Ellis Ave., Chicago, Ill.
Dempster, A. J., Ph. D., University of Chicago, Chicago, Ill. (Physics.)
DeTurk, Ernest E., Ph. D., 707 W. Green St., Urbana, Ill. (Agriculture.)
Dilts, Charles D., A. B., 3121 Fairfield Ave., Fort Wayne, Ind. (Chemistry.)
Downie, Thomas R., 1216 N. Kellogg St., Galesburg, Ill. (Geology.)
Downing, Elliot R., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Dufford, R. T., 104 Physics Bldg., University of Missouri, Columbia, Mo. (Physics.)
Earle, C. A., M. D., DesPlaines, Ill. (Botany.)
East, Clarence W., M. D., F. A. S. C., 326 W. Jackson St., Springfield, Ill. (Preventive Medicine.)
Eaton, Scott V., Ph. D., University of Chicago, Chicago, Ill. (Botany.)
Ehrman, E. H., M. E., Homan Ave. and Fillmore St., Chicago, Ill.
Eifrig, C. W. G., 504 Monroe Ave., Oak Park, Ill., (Ornithology, Botany, Zoology.)
Ekblaw, George E., A. M., 445 Hamilton Ave., Palo Alto, Calif. (Geology.)
Ekblaw, W. E., Ph. D., 6 Woodbine St., Worcester, Mass. (Geology.)
Eklund, Edwin G., A. B., A. M., 1451 So. Lincoln St., Springfield, Ill. (Psychology.)
Eldredge, Arthur G., University of Illinois, Urbana, Ill. (Photography.)
Eller, W. H., S. B., State Teachers College, Macomb, Ill. (Physics.)
Elliott, A. T., B. S., P. O. Box 1221, East Chicago, Ind. (Science.)
Englis, Duane T., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.)
Evans, Frank N., M. D., 407 S. Seventh St., Springfield, Ill. (Medicine.)
*Ewing, Dr. H. E., Dept. of Insectology, Smithsonian Institute, Washington, D. C. (Biology.)
Farwell, Mrs. Francis C., Edgewood, Lake Forest, Ill.
Faught, Eva E., 841 S. English Ave., Springfield, Ill. (Bacteriology.)
Faust, Mildred E., M. S., Kidder Junior College, Kidder, Mo. (Botany.)
Ferguson, Harry F., S. B., Department Public Health, Springfield, Ill. (Sanitary Engineer.)
Feuer, Bertram, B. S., M. S., 2634 Argyle St., Chicago, Ill. (Chemistry, Bacteriology.)
Finley, C. W., M. A., The Lincoln School, Teachers College, Columbia University, New York. (Zoology.)
*Fisher, Fannie, Asst. Curator, State Museum, Springfield, Ill. (Gen. Interest.)
Flint, W. P., Asst. State Entomologist, 1006 South Orchard St., Urbana, Ill.
Foard, Castle W., M. S., 990 E. Brooks St., Galesburg, Ill. (Physics.)
Foberg, J. Albert, B. S., Camp Hill, Pa. (Mathematics.)

Folsom, Justus W., Sc. D., Tallulah, La., (Entomology.)
Franing, E. C., M. D., 404 Bank of Galesburg Bldg., Galesburg, Ill. (Medicine.)
Franing, Russell, A. B., Dundee Community High School, Dundee, Ill. (Chemistry.)
Frank, O. D., 5825 Drexel Ave., Chicago, Ill. (Biology.)
French, G. H., M. A., Herrin Hospital, Herrin, Ill. (Botany, Entomology.)
Frison, Theodore H., 316A. Natural History Building, University of Illinois, Urbana, Ill. (Entomology, General Biology.)
Fryxell, Fritiof M., M. A., Augustana College, Rock Island, Ill. (Geology.)
Fuller, **Margaret B.**, Ph. D., Northwestern University, Evanston, Ill. (Geology.)
Funk, Donald S., B. A., Sangamo Electric Co., Springfield, Ill.
Gantz, R. A., 411 N. Talley St., Muncie, Ind. (Botany.)
Gault, B. T., 564 N. Main St., Glen Ellyn, Ill. (Ornithology.)
Geauque, H. A., 531 Lombard St., Galesburg, Ill. (Chemistry.)
Gerard, R. W., B. S., 2811 Cottage Grove Ave., Chicago, Ill.
Gerhard, Wm. J., Field Museum, Chicago, Ill.
Gerould, T. F., M. D., 115½ N. Locust St., Centralia, Ill. (Medicine.)
Glattfeld, J. W. E., Ph. D., University of Chicago, Chicago, Ill. (Chemistry.)
Goode, J. Paul, Ph. D., University of Chicago, Chicago, Ill. (Geography.)
Gore, G. W., M. D., 231 N. McCleamsboro St., Benton, Ill. (Medicine.)
Gorrell, **T. J. H.**, M. D., Chicago Heights, Ill. (Medicine.)
Gould, William C., A. B., M. A., State Teachers College, DeKalb, Ill. (Geography.)
Gradle, Harry S., M. D., 22 E. Washington St., Chicago, Ill. (Ophthalmology.)
Graham, R., University of Illinois, Urbana, Ill. (Animal Pathology.)
•**Grant, U. S.**, Ph. D., Northwestern University, Evanston, Ill. (Geology.)
Green, Bessie, M. A., University of Tennessee, Knoxville, Tenn. (Zoology.)
Greenman, J. M., Ph. D., Missouri Botanical Garden, St. Louis, Mo. (Botany.)
Griffith, C. R., Ph. D., University of Illinois, Urbana, Ill. (Psychology.)
Gronemann, Carl F., 310 N. Liberty St., Elgin, Ill. (Artist, Naturalist.)
Gurley, William F. E., 6151 University Ave., Chicago, Ill. (Paleontology.)
Haas, William H., M. A., Northwestern University, Evanston, Ill. (Geography.)
Hagler, Mrs. E. E., 1900 W. Lawrence Ave., Springfield, Ill.
•Hale, John A., M. D., 6110 Eileen St., Los Angeles, Cal. (Medicine.)
Hall, Earl H., 999 Spring Garden St., Greensboro, N. C.
Hanna, Joseph V., A. M., Joliet High School and Junior College, Joliet, Ill. (Psychology.)
Hansen, Paul, 6 N. Michigan Ave., Chicago, Ill. (Sanitation.)
Hanson, Alyda C., B. S., Chicago Normal College, 68th St. and Stewart Ave., Chicago, Ill. (Geography, Geology.)
Hardin, Sarah M., Ph. B., 402 W. Walnut St., Carbondale, Ill. (Biology.)
Harding, H. A., Ph. D., P. O. Box 834, Detroit, Mich. (Bacteriology.)
Harland, Marion B., B. S., 655 Old Agricultural Bldg., Urbana, Ill. (Soils.)
Harkins, William D., Ph. D., University of Chicago, Chicago, Ill. (Chemistry.)
Hartsough, Ralph C., B. S., A. M., 421 W. 114th St., New York, N. Y.
Hauberg, John H., B. S., LL. B., 23d St. Hill and 13th Ave., Rock Island, Ill. (Botany.)
Hauberg, Mrs. John H., 23d St. Hill and 13th Ave., Rock Island, Ill.
Haupt, Arthur W., University of California, Los Angeles, Cal. (Botany.)
Hawkes, Joseph B., A. B., 605 W. University Ave., Urbana, Ill. (Botany.)
Hawthorne, W. C., B. A., B. S., Crane Junior College, Chicago, Ill. (Physics.)
Hay, Logan, B. A., 1220 S. Grand Ave. W., Springfield, Ill. (Mathematics.)
Hazell, E. F., D. D. S., 608 E. Capitol Ave., Springfield, Ill., (Meteorology.)
Heflin, H. N., M. D., Kewanee, Ill. (Medicine.)
Hemenway, Henry B., M. D., 620 Amos Ave., Springfield, Ill. (Public Health.)
Henkel, H. B., M. D., 401 E. Capitol Ave., Springfield, Ill. (Medicine.)
Herndon, R. F., M. D., 407 S. Seventh St., Springfield, Ill. (Medicine.)
Herrick, C. Judson, Ph. D., University of Chicago, Chicago, Ill. (Anatomy, Neurology.)
Higgins, George M., Ph. D., Inst. Experimental Medicine, Rochester, Minn. (Zoology.)
Hildebrand, L. E., M. A., New Trier Township High School, Kenilworth, Ill. (Zoology.)
•**Hill, W. K.**, Carthage College, Carthage, Ill. (Biology.)
Hinchliff, Grace, 715 N. Broad St., Galesburg, Ill.
Hines, Murray A., Ph. D., 1610 Oak Ave., Evanston, Ill. (Chemistry.)
Hoffman, Frank F., M. D., 3117 Logan Blvd., Chicago, Ill. (Phys-Surg.)
Holgate, T. F., LL. D., 617 Library St., Evanston, Ill. (Mathematics.)
Holmes Manfred J., B. L., 703 Broadway, Normal, Ill. (Social and Education.)
Holtz, F. C., B. S., 1358 Dial Court, Springfield, Ill. (Mathematics, Physics.)
Honey, Edwin E., B. S., State College of Washington, Pullman, Washington. (Plant Pathology, Botany, Entomology.)
Hoover, Harvey D., Ph. D., S. T. D., Carthage, Ill.

Hopkins, B. Smith, Ph. D., University of Illinois, Urbana, Ill. (Inorganic Chemistry.)
Horrell, C. R., B. S., Sangamo Electric Co., Springfield, Ill. (Electrical Engineering.)
Hottes, C. F., Ph. D., University of Illinois, Urbana, Ill. (Botany.)
Houdek, Paul, Rantoul, Ill. (Biology.)
Huey, Walter B., M. D., Elgin, Joliet and Eastern Ry., Joliet, Ill. (Medicine.)
Hull, Thos. G., Ph. D., State Board of Health, Springfield, Ill. (Health.)
Hunter, Geo. W., Ph. D., Knox College, Galesburg, Ill. (Biology.)
*Hutton, J. Gladden, M. S., State College, Brookings, South Dakota. (Geology.)
Illinois State Library, State House, Springfield, Ill.
Isenbarger, Jerome, B. S., 2200 Greenleaf Ave., Chicago, Ill. (Zoology.)
Jane, Wm. T., 5 N. Wabash Ave., Chicago, Ill., (Bausch & Lomb Optical Co.)
Jelliff, Fred R., B. A., Editor Daily Republican Register, Galesburg, Ill. (Geology.)
Jenks, Ira J., M. S., State Teachers College, DeKalb, Ill. (Chemistry.)
Jensen, Jens, Ravina, Ill. (Geology, Botany.)
Johnson, George F., 625 Black Ave., Springfield, Ill. (Astronomy.)
Johnson, John H., B. Ed., Sup't. of Schools, Tremont, Ill. (Biology.)
Johnson, T. Arthur, M. D., 7th St. and 4th Ave., Rockford, Ill. (Medicine.)
Jones, Elmer E., Ph. D., Northwestern University, Evanston, Ill. (Mental Development, Heredity.)
Jurica, Hilary S., St. Procopius College, Lisle, Ill. (Botany.)
Karraker, Edward L., Jonesboro, Ill. (Forestry.)
Kauffman, J. S., M. D., 233 York St., Blue Island, Ill. (Medicine.)
Kelso, Margut A., 6 Cedar Crest, Normal, Ill. (Chemistry.)
Kempton, F. E., M. S., Bureau of Plant Industry, Dept. of Agriculture, Washington, D. C. (Plant Pathology, Botany.)
Kennicott, Ransom, 547 Cook Co. Bldg., Chicago, Ill. (Forestry.)
Kibbe, Alice, Carthage, Ill.
Kirn, George J., Ph. D., D. D., Northwestern College, Naperville, Ill. (Psychology, Philosophy.)
Kline, R. G., M. D., Hoopeston, Ill. (Medicine.)
Kneale, Elmer J., Illinois State Register, Springfield, Ill. (Astronomy.)
*Knipp, Charles T., Ph. D., University of Illinois, Urbana, Ill. (Physics.)
Koch, Fred Conrad, Ph. D., 1903 E. 72nd St., Chicago, Ill. (Physiological Chemistry.)
Kohl, F., Centralia, Ill. (Entrepreneur.)
Krey, Frank, B. S., State Geological Survey, Urbana, Ill. (Geology.)
Kudo, Rokusaburo, University of Illinois, Urbana, Ill. (Zoology.)
Kuh, Sidney, M. D., 30 N. Michigan Ave., Chicago, Ill. (Medicine.)
Lamar, J. Everts, B. S., State Geological Survey Division, Urbana, Ill. (Geology.)
Lambert, Earl L., B. S., Dakota, Ill. (Botany, Zoology.)
Land, W. J. G., Ph. D., University of Chicago, Chicago, Ill. (Botany.)
Langford, George, B. S., McKenna Process Co., Joliet, Ill. (Paleontology.)
Lanphier, Robert C., Ph. B., Sangamo Electric Co., Springfield, Ill. (Electricity.)
Larson, Karl, B. A., Augustana College, Rock Island, Ill. (Chemistry.)
Lathrop, W. G., Principal Twp. High School, Johnston City, Ill. (Geology.) Geography.)
Laves, Kurt, Ph. D., University of Chicago, Chicago, Ill. (Astronomy, Mathematics.)
Lawson, Edwin W., 400 Jefferson Ave., Elgin, Ill.
Leighton, Morris Morgan, Ph. D., Chief, Illinois Geological Survey Division, Urbana, Ill. (Geology.)
Leonard, Thomas H., M. D., 509 S. Sixth St., Springfield, Ill. (Medicine.)
Lerche, Thorleif I., D. D. S., 3012 E. 92nd St., Chicago, Ill. (Medicine.)
Lewis, Howard D., Ph. D., University of Michigan Medical School, Ann Arbor, Mich. (Physiological Chemistry.)
Lewis, Julian H., D. D., Ricketts Laboratory, University of Chicago, Chicago, Ill. (Pathology.)
Linder, O. A., 208 N. Wells St., Chicago, Ill.
Linkins, R. M., M. A., 706 Broadway, Normal, Ill. (Zoology.)
Logsdon, Mrs. M. I., A. M., Ph. D., University of Chicago, Chicago, Ill. (Mathematics.)
Longden, A. C., Ph. D., Knox College, Galesburg, Ill. (Physics.)
Lukens, Herman T., Ph. D., 330 Webster Ave., Chicago, Ill. (Geography.)
Lutes, Neil, 1595 Atlantic St., Dubuque, Iowa. (Chemistry.)
Mackie, Arthur D., 400 E. Monroe St., Springfield, Ill. (Electricity.)
Mac Millan, W. D., Ph. D., University of Chicago, Chicago, Ill. (Astronomy.)
Maddock, Rosa G., B. S., 9648 Vanderpool Ave., Chicago, Ill. (Zoology.)
Madison, Wm. D., M. D., Eureka, Ill. (Medicine.)
Magill, Henry P., 175 W. Jackson Blvd., Chicago, Ill. (Sociology, Finance.)
Malinovsky, A., Chemical Engineer, Washington Iron Works, Los Angeles, California. (Chemistry.)
Mann, A. L., M. D., 392 E. Chicago St., Elgin, Ill. (Medicine.)
Mann, Jessie R., B. S., State Teachers College, DeKalb, Ill. (Biology.)
Marks, Sarah, Pecatonica, Ill. (Biology.)

Martin, Geo. W., Ph. D., Washington and Jefferson College, Washington, Penn. (Biology.)
Mason, Arthur J., 5715 Woodlawn Ave., Chicago, Ill.
McClure, S. M., McKendree College, Lebanon, Ill.
McCollow, Roy M., 101 Broadway, Normal, Ill. (Geography.)
McCoy, Herbert N., Ph. D., 1623 Hyde Park Blvd., Chicago, Ill. (Chemistry.)
McDavitt, Neva, 303 North St., Normal, Ill. (Geography.)
McDougall, W. B., Ph. D., University of Illinois, Urbana, Ill. (Botany.)
McEvoy, S. Aleta, B. S., Rockford High School, Rockford, Ill. (Chemistry.)
McGinnis, Helen A., 6400 S. Maplewood Ave., Chicago, Ill. (Gen. Science.)
McKee, W. A., D. D. S., East Side Square, Benton, Ill. (Dentist.)
McMaster, Archie J., 600 Ravine Ave., Peoria, Ill. (Physics, Chemistry.)
McShane, John J., M. D., 811 S. State St., Springfield, Ill. (Medicine.)
Mecham, John B., Ph. D., 118 S. Center St., Joliet, Ill.
Metcalf, C. S., Ph. D., University of Illinois, Urbana, Ill. (Entomology.)
Metzner, Albert E., M. S., 24 Marshner St., Plymouth, Wis. (Geology, Physics.)
Michelson, A. A., LL. D., University of Chicago, Chicago, Ill. (Physics.)
Miller, Harry Milton, Jr., Washington University, St. Louis, Mo. (Zoology.)
Miller, Isiah Leslie, M. A., Station A, Box 53, Brookings, South Dakota. (Mathematics, Chemistry.)
Miller, P. H., High School, Henning, Ill. (Biology.)
Miller, R. B., M. F., Winona, Minn. (Forestry, Ecology.)
Milton, Charles, B. A., University of Illinois, Urbana, Ill. (Geology.)
Mitchell, Catherine, A. B., 144 Fairbank Road, Riverside, Ill. (Botany, Ornithology.)
Mongerson, Oscar V., B. S., State Normal University, Normal, Ill. (Physics.)
Montgomery, C. E., M. S., State Teachers College, DeKalb, Ill. (Biology.)
Moore, Clarence E., B. A., University of Illinois, Urbana, Ill. (Botany.)
Moore, Eugenia, 6 Cedar Crest, Normal, Ill. (Chemistry.)
Morgan, Wm. E., M. D., 1016 Hyde Park Blvd., Chicago, Ill. (Medicine.)
Morris, Edward A., M. D., 717 E. Capitol Ave., Springfield, Ill. (Medicine.)
Moulton, F. R., Ph. D., University of Chicago, Chicago, Ill. (Astronomy.)
Mumford, H. W., B. S., University of Illinois, Urbana, Ill. (Animal Husbandry, Agriculture.)
Murrah, Frank C., M. D., 105½ N. Park Ave., Herrin, Ill. (Medicine.)
Mylius, L. A., S. B., M. E., 312 N. Neil St., Champaign, Ill. (Geology.)
Nadler, Walter H., M. D., 30 N. Michigan Ave., Chicago, Ill. (Medicine.)
Neifert, Ira E., M. S., 922 E. Bowry St., Iowa City, Iowa. (Chemistry.)
Nelson, C. Z., 534 Hawkingson Ave., Galesburg, Ill. (Botany.)
Newcomb, Rexford, M. A., University of Illinois, Urbana, Ill. (Engineering Applications.)
Newell, M. J., M. A., 2017 Sherman Ave., Evanston, Ill.
Newman, H. H., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Nicholson, F. M., 611 So. Ashland Blvd., Chicago, Ill. (Anatomy.)
Noe, Adolf Carl, University of Chicago, Chicago, Ill. (Botany.)
Nollen, Neil, High School, Springfield, Ill. (Chemistry.)
North, E. M., B. A., 694 Garland Place, DesPlaines, Ill. (Geology, Astronomy, Pedagogy.)
Noyes, Jr., William Albert, D. Sc., University of Chicago, Chicago, Ill. (Chemistry.)
Obenchain, Jeanette Brown, Ph. B., 6130 Dorchester Ave., Chicago, Ill. (Anatomy.)
Ogilvy, Robert S., 807 Crescent Building, Glen Ellyn, Ill.
Ondrak, Ambrose L., B. A., St. Procopius College, Lisle, Ill. (Physics.)
Ozment, Arel, 806 Washington Ave., Johnston City, Ill. (General.)
Packard, W. H., Ph. D., Bradley Polytechnic Institute, Peoria, Ill. (Biology.)
Paddock, Walter R., M. D., 904 State St., Lockport, Ill. (Medicine.)
*Parr, S. W., M. S., University of Illinois, Urbana, Ill. (Chemistry.)
Parson, S. F., State Teachers College, DeKalb, Ill. (Mathematics.)
Patterson, Alice J., Illinois State Normal University, Normal, Ill. (Entomology, Nature Study.)
Patterson, Cecil F., B. S., University of Saskatchewan, Saskatoon, Canada. (Horticulture.)
Patton, Charles L., M. D., 407 S. Seventh St., Springfield, Ill. (Medicine.)
Patton, Fred P., M. D., Glencoe, Ill. (Medicine.)
Pearsons, H. P., 1816 Chicago Ave., Evanston, Ill.
Peterson, Harvey A., 502 Normal Ave., Normal, Ill.
Phipps, Charles Frank, B. S., M. S., State Teachers College, DeKalb, Ill. (Physics, Chemistry.)
Pieper, Charles J., University of Chicago, Chicago, Ill. (General Science.)
Piapp, F. W., 4140 N. Keeler Ave., Chicago, Ill. (Botany, Geology.)
Platt, Robert S., Ph. D., University of Chicago, Chicago, Ill. (Geography.)
Plummer, Beulah A., B. S., Lowell, Indiana. (Physiology, Zoology.)
Plunkett, O. A., Ph. D., State Normal University, Normal, Ill. (Botany.)
Poling, J. A., M. D., Crum-Forster Bldg., Freeport, Ill. (Medicine.)
Pollock, M. D., M. D., Powers Bldg., Decatur, Ill. (Medicine, Surgery.)
Poor, R. S., B. S., 1008 W. Green St., Urbana, Ill. (Geology.)
Porter, Charles L., A. B., B. S., 484 Northwestern Avenue, W. Lafayette, Ind. (Botany, Plant Pathology.)
Quirke, T. T., Ph. D., University of Illinois, Urbana, Ill. (Geology.)

*Radcliffe, H. H., Principal of Night School, 1346 W. Macon St., Decatur, Ill. (Physics, Chemistry.)
Ransom, James H., B. S., James Millikin University, Decatur, Ill. (Chemistry.)
Rauth, Andy Fred., R. F. D. No. 9, Booneville, Ind. (Biology.)
Reagan, Albert B., A. B., A. M., Cornfields, Arizona. (Paleontology.)
Redfield, Casper L., 526 Monadnock Block, Chicago, Ill. (Evolution.)
Renich, Mary E., Ph. D., 306 Smarts St., Abingdon, Ill. (Botany.)
Rew, Irwin, A. B., 217 Dempster St., Evanston, Ill.
Richardson, Baxter K., A. B., Dept. of Public Health, Springfield, Ill. (Public Health.)
Richardson, R. E., Ph. D., Vivarium, Cor. Wright and Healy Sts., Champaign, Ill. (Zoology.)
Ridgway, Robert, M. S., 1030 S. Morgan St., Route 7, Olney, Ill. (Ornithology.)
Rinker, Jacob Arron, B. S., Eureka, Ill. (Physics.)
Rodebush, W. H., University of Illinois, Urbana, Ill. (Chemistry.)
Romer, A. S., Ph. D., University of Chicago, Chicago, Ill. (Paleontology.)
Root, Clarence J., U. S. Weather Bureau, Springfield, Ill. (Climatology.)
Rose, William C., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.)
Rudnick, Paul, 10407 S. Leavitt St., Chicago, Ill. (Chemistry.)
Salter, Allen, Lena, Ill. (Medicine.)
Salzberg, Paul, 875 E. Losy St., Galesburg, Ill. (Chemistry.)
Sampson, H. C., Ph. D., Ohio State University, Columbus, Ohio.
Savage, T. E., Ph. D., University of Illinois, Urbana, Ill. (Stratigraphic Geology.)
Shantz, Orpheus M., Room 1649, 10 S. LaSalle St., Chicago, Ill. (Birds, Plants.)
Schaub, Edward L., Ph. D., 2437 Sheridan Road, Evanston, Ill. (Psychology.)
Schmidt, Otto L., M. D., 5 So. Wabash Ave., Chicago, Ill. (History.)
Schmoll, Hazel Marguerite, B. E., M. S., 1437 Pennsylvania Ave., Denver, Colo. (Botany.)
Schulz, W F., Ph. D., University of Illinois, Urbana, Ill. (Physics.)
Scott, R. A., M. S., State Normal University, Carbondale, Ill. (Chemistry.)
Sears, O. H., 606 E. Chalmers St., Champaign, Ill. (Chemistry.)
Shamel, C. H., Ph. D., Taylorville, Ill. (Chemistry.)
Shank, Marjorie M., A. M., 492 W. Walnut St., Carbondale, Ill. (Geography.)
Shelford, V. E., Ph. D., Vivarium Bldg., Wright and Healy Sts., Champaign, Ill. (Zoology, Ecology.)
Shull, Chas. A., Ph. D., University of Chicago, Chicago, Ill. (Botany, Plant Physiology.)
Siedenburg, Frederick, M. A., 1076 West Roosevelt Road, Chicago, Ill. (Sociology.)
Simmons, Marguerite L., B. S., M. A., 325 Melrose Ave., Centralia, Ill. (Biology.)
Simonds, O. C., 1101 Buena Ave., Chicago, Ill. (Botany.)
Simons, Etoile B., Ph. D., 7727 Colfax Ave., Chicago, Ill. (Botany.)
Singer, H. Douglas, M. D., 25 E. Washington St., Chicago, Ill. (Psychiatry.)
Slaught, H. E., Ph. D., Sc. D., University of Chicago, Chicago, Ill. (Mathematics.)
Slocum, A. W., University of Chicago, Chicago, Ill.
Slye, Maud, A. B., 5836 Drexel Ave., Chicago, Ill.
Smallwood, Mabel E., 550 Surf St., Chicago, Ill. (Zoology.)
Smith, Arthur Bessey, B. S., 2324 Hartzell St., Evanston, Ill. (Telephony.)
*Smith, C. H., M. E., 5517 Cornell Ave., Chicago, Ill. (Physics.)
Smith, Clarence R., B. S., Aurora College, Aurora, Ill. (Physics.)
Smith, Mrs. Eleanor C., B. S., 104 Winston Ave., Joliet, Ill. (Biology.)
Smith, George Hume, Ph. D., 804 N. Michigan St., Urbana, Ill. (Botany.)
Smith, Grant, M. S., 1738 W. 104 St., Chicago, Ill. (Zoology.)
Smith, Guy W., B. S., Rockford High School, Rockford, Ill. (Botany.)
Smith, Jesse L., Supt. of Schools, Highland Park, Ill.
Smith, K. K., Ph. D., Northwestern Univ., Evanston, Ill. (Physics.)
Smith, Merlin G., A. M., Ph. D., Greenville College, Greenville, Ill. (Mathematics.)
Smith, R. S., Ph. D., University of Illinois, Urbana, Ill. (Chemistry and Physics of Soils.)
Smith, S. S., Steeleville, Randolph Co., Ill. (Vocational and Physical Education.)
Snider, Alvin B., M. D., Blue Island, Ill. (Medicine.)
Snider, H. J., B. S., University of Illinois, Urbana, Ill. (Soils, Agri.)
Sonnenschein, Robert, M. D., 4518 Woodlawn Ave., Chicago, Ill. (Medicine.)
Spicer, C. E., 100 Sherman St., Joliet, Ill. (Chemistry.)
Spooner, Charles S., A. B., A. M., 1436 7th St., Charleston, Ill. (Zoology.)
Stabin, George W., M. D., First National Bank Bldg., Springfield, Ill. (Medicine.)
Stansfield, John, M. A., M. S., State School of Mines, Butte, Mont. (Geology.)
Stark, John Thomas, M. A., 749 Sherman Ave., Evanston, Ill. (Geology.)
Steagall, Mary M., Ph. B., 808 S. Illinois Ave., Carbondale, Ill. (Botany.)
Stevens, F. L., Ph. D., University of Illinois, Urbana, Ill. (Plant Pathology.)
Stillians, A. W., M. D., 819 East 50th St., Chicago, Ill. (Medicine.)
Stover, E. L., State Teachers College, Charleston, Ill. (Botany.)

Stover, Mrs. E. L., M. S., 930 Second St., Charleston, Ill. (Botany.)
Strong, Harriet, B. S., 192 E. Maple Ave., Downers Grove, Ill. (Biology.)
Struble, R. H., A. B., 4481 Sheridan Ave., Detroit, Mich. (Physics.)
Swan, W. S., M. D., Cor. Main and Walnut Sts, Harrisburg, Ill. (Medicine.)
Tatum, Arthur L., Ph. D., M. D., University of Chicago, Chicago, Ill. (Physiology, Pharmacology.)
Taylor, Mildred E., A. B., A. M., Knox College, Galesburg, Ill. (Mathematics.)
Tehon, Leo. R., A. B., M. A., University of Illinois, Urbana, Ill. (Botany, Plant Pathology.)
Tharaldsen, C. E., M. A., 719 Emerson St., Evanston, Ill. (Zoology.)
Thomas, E. T., M. A., Willow Grove, Tennessee. (Geology.)
Thomas, Gertrude M., 1003 N. Court St., Rockford, Ill. (Biology.)
Thomas, L. J., 301 Natural History Bldg., University of Illinois, Urbana, Ill.
Thompson, Louis T. E., Ph. D., Naval Proving Station, Dahlgren, Va. (Physics.)
Thompson, O. B., M. D., 201 S. Washington Ave., Carbondale, Ill. (Medicine.)
Thurlimann, Leota, 3856 Gladys Ave., Chicago, Ill. (Botany.)
Thurston, Fredus A., 1361 E. 57th St., Chicago, Ill.
Tiffany, L. Hanford, Ohio State Univ., Columbus, Ohio. (Botany.)
*__Townsend, E. J.__, Ph. D., Univ. of Illinois, Urbana, Ill. (Mathematics.)
Townsend, M. T., B. S., St. John's College, Annapolis, Md. (Animal Ecology.)
Townsley, Fred D., B. A., James Millikin University, Decatur, Ill.
Trapp, A. R., M. D., Illinois National Bank Bldg., Springfield, Ill. (Medical Diagnosis.)
Turner, Lewis M., B. S., 802 W. Illinois St., Urbana, Ill. (Botany.)
Turton, Chas. M., M. A., 2055 E. 72nd Place, Chicago, Ill. (Physics.)
Tuttle, H. H., M. D., Illinois Bank Bldg., Springfield, Ill. (Medicine.)
Ulrich, Katherine, Ph. B., 304 N. Oak Park Ave., Oak Park, Ill. (Geology, Geography, Botany.)
Utzig, Esther W., A. B., 1115 W. Illinois St., Urbana, Ill. (Geography.)
Van Cleave, H. J., Ph. D., University of Illinois, Urbana, Ill. (Zoology.)
Van Cleet, Eugene, B. S., Ohio State University, Columbus, Ohio. (Geography, Climatology.)
Van Tuyl, Francis M., Ph. D., Colorado School of Mines, Golden, Colo. (Geology.)
Vestal, A. G., Ph. D., Stanford University, Cal. (Ecology.)
Waldo, Jennie E., 1204 Third Ave., Rockford, Ill. (Biology.)
Walker, Ellis David, M. D., B. Sc., 5519 University Ave., Chicago, Ill. (Pedagogical Med., Biol., Agri.)
Walsh, John, 1120 S. West St., Galesburg, Ill. (Water Supply.)
Wanless, Harold R., Ph. D., 1003 W. Oregon St., Urbana, Ill. (Geology.)
Warbrick, John C., M. D., M. C., 306 E. 43rd St., Chicago, Ill. (Birds, Nature Study.)
Ward, Harold B., B. S., Northwestern Univ., Evanston, Ill. (Geology, Geography.)
Waterman, Warren G., Ph. D., Northwestern University, Evanston, Ill. (Botany.)
Watson, F. R., Ph. D., Dept. of Physics, University of Illinois, Urbana, Ill.
Weaver, George H., M. D., 629 S. Wood St., Chicago, Ill. (Medicine, Bacteriology.)
Weber, H. C. P., Ph. D., Westinghouse Electric Co., Pittsburgh, Pa. (Chemistry.)
Weckel, Ada. L., M. S., Twp. High School, Oak Park, Ill. (Zoology.)
Weese, Asa Orrin, University of Oklahoma, Norman, Oklahoma.
Weichelt, A., M. D., Barrington, Ill. (Medicine.)
Welker, William H., Ph. D., Univ. of Illinois College of Medicine, 508 S. Honore St., Chicago, Ill. (Biological Chemistry.)
Wells, M. M., Ph. D., General Biological Supply House, 1177 E. 55th St., Chicago, Ill. (Zoology.)
Wentworth, Edward N., B. S., M. S., Armour's Bureau of Agricultural Research and Economics, Chicago, Ill. (Genetics and Economics.)
Whitmore, Frank C., Ph. D., Northwestern University, Evanston, Ill. (Organic Chemistry.)
Whitney, Worallo, A. M., 5743 Dorchester Ave., Chicago, Ill. (Botany.)
Whitten, J. H., Ph. D., 7111 Normal Ave., Chicago, Ill. (Botany.)
Williams, E. G. C., M. D., 316 The Temple, Danville, Ill. (Medicine, Clinical Pathology.)
Willier, Benj. H., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Willman, H. B., 705 S. Goodwin St., Urbana, Ill. (Geology.)
Wilson, J. Gordon, M. A., 5755 Kenwood Ave., Chicago, Ill. (Otology.)
Windsor, Mrs. P. L., 701 Michigan Ave., Urbana, Ill. (Entomology.)
Winstrom, Harry J., A. B., M. A., Supt. of Schools, Springfield, Ill. (Education.)
*__Winter, S. G.__, M. A., Lombard College, Galesburg, Ill. (Histology.)
Witt, J. C., Ph. D., 881 Cornelia Ave., Chicago, Ill. (Chemistry.)
Witzemann, Edgar J., Ph. D., Mayo Foundation, Rochester, Minn. (Chemistry.)

Wolkoff, M. I., Ph. D., Agricultural Experiment Station, Urbana, Ill. (Soil Fertility.)
Wood, F. E., 804 N. Evans St., Bloomington, Ill. (Biology.)
Woodruff, Frank M., Curator of Chicago Academy of Science, Chicago, Ill.
Woods, F. C., 100 N. Cherry St., Galesburg, Ill. (Physics.)
Worsham, Walter B., A. B., Paris, Ill. (Physics.)
Wright, Frank, M. D., 5 S. Wabash Ave., Chicago, Ill. (Biological Chemistry.)
Wright, Paul R., B. A., Michigan Ave. and Oak St., Highland Park, Ill. Geology.)
Wynne, Ross B., A. B., 250 E. 11th St., Chicago, Ill. (Botany.)
Young, Mrs. J. D., M. S., Windermere Hotel, 56th St. and Cornell Ave., Chicago, Ill. (Zoology.)
Zehren, Karl C., Flanigan, Ill. (Agriculture.)
*Zetek, James, A. M., Box 245, Ancon, Panama Canal Zone. (Entomology.)
Zimmerman, Augustine G., 30 N. Michigan Ave., Chicago, Ill. (Biological Science.)
Zoller, C. H., M. D., Hughes Bldg., Litchfield, Ill. (Medicine.)

SCIENTIFIC SOCIETIES AFFILIATED WITH THE ACADEMY.

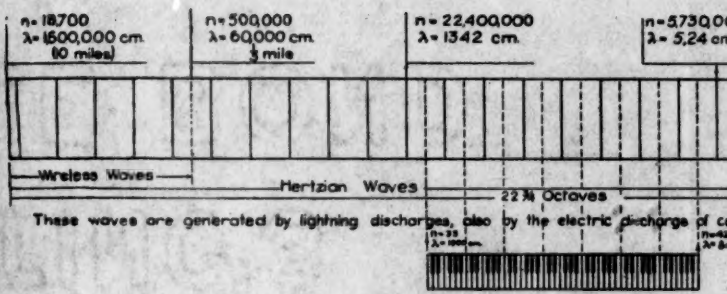
Burrill Botany Club, 204 Natural History Bldg., University of Illinois, Urbana, Ill.
Englewood Biology Club, Englewood, Illinois.
Illinois Nature Study Society of Elgin, 310 N. Liberty St., Elgin, Ill.
Joliet Biology Club, Joliet, Ill.
Knox County Academy of Science, Galesburg, Ill., Fred R. Jelliff, President.
Normal Science Club, Illinois State Normal University, Normal, Ill.
Rockford Nature Study Society, 210 N. Avon St., Rockford, Ill.
Science Club, State Normal University, Carbondale, Ill.
Sigma Xi, University of Chicago Chapter, Chicago, Ill.
Sigma Xi, University of Illinois Chapter, Urbana, Ill.
The Botany Club of Joliet, Joliet, Ill.
The Chicago Academy of Science, Chicago, Ill.

HIGH SCHOOL SCIENCE CLUBS.

Boys' Science Club, High School, Galesburg, Ill.
Danville Science Club, High School, Danville, Ill.
Englewood High School General Science Club, 62nd St. and Stewart Ave., Chicago, Ill.
Eureka Science Club, Eureka Township High School, Eureka, Ill.

Range

Showing, n, th
where $n\lambda$ =

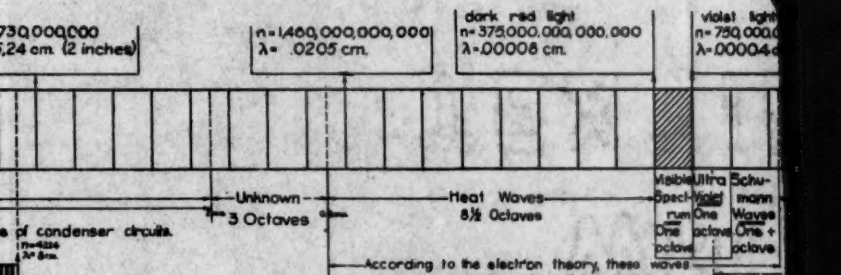


These waves are generated by lightning discharges, also by the electric discharge of c

Seven octaves is the range of the ordinary piano. It should be remembered that sound-waves are not electromagnetic waves. They are compressional waves in air that travel with only one millionth the velocity of electromagnetic waves.

nge of Electromagnetic Waves

g, n, the number of vibrations per second and, λ, the wavelength
nλ = v, v being the velocity of light, equal to 30,000,000,000 cm. per second.



According to the electron theory, these waves are set up by electrons when they revolve around atoms millions of times per second. A solid heated to incandescence gives all these waves, but a rarefied gas when heated gives only a few scattered waves characteristic of its spectrum.

If the difference in wavelength for the octave of visible light from violet (.00004 cm.) to dark red (.00008 cm.) is represented by a distance of 1 inch, the corresponding distance for the last octave of wireless (600,000 to 1,600,000 cm.) will be represented by 316,000 miles, or 1⅓ times the distance to the moon.

FIG. 1.

Range of Electromagnetic Waves

Showing, n, the number of vibrations per second and, λ, the wavelength where $n\lambda = v$, v being the velocity of light, equal to 30,000,000,000 cm. p

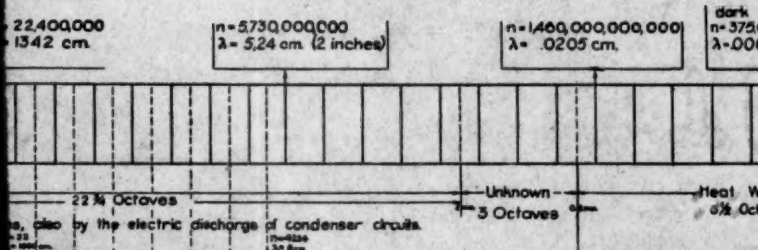
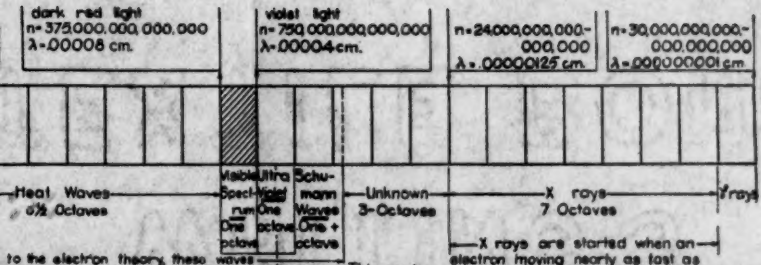

22,400,000
1342 cm.
n = 5,730,000,000
λ = 5.24 cm. (2 inches)
n = 1,460,000,000,000
λ = .0205 cm.
dark
n = 375
λ = .00
2 2¼ Octaves
Unknown
3 Octaves
Heat. W
Oct
e, also by the electric discharge of condenser circuits.
even octaves is the range of the
dinary piano. It should be remem-
red that sound-waves are not
ectromagnetic waves. They are
mpressional waves in air that trav-
with only one millionth the velocity
electromagnetic waves.
According to the ele
are set up by electrons
ome millions of times per
condesence gives all the
when heated gives only
acteristic of its spectru
If the difference in wa
ble light from violet (.00
is represented by a dist
ing distance for the las
(600,000 cm.) will be re
1⅓ times the distance f

FIG. I.

Waves

velength
,000 cm per second.



to the electron theory, these waves
electrons when they revolve around at-
times per second. A solid heated to in-
ves all these waves, but a rarefied gas
gives only a few scattered waves char-
's spectrum.

This region—about 4½ octaves—should be included with X-rays. The X-ray spectrum is now (1924) known to extend well up into the ultra-violet.

nce in wavelength for the octave of visi-
violet (.00004 cm) to dark red (.00008 cm)
by a distance of 1 inch, the correspond-
r the last octave of wireless (600,000 to
will be represented by 316,000 miles, or
distance to the moon.

X rays are started when an electron moving nearly as fast as light strikes an obstacle. It sends a wave pulse out into the surrounding ether that travels with the speed of light. The effect is analogous to the case when a bullet with a high velocity strikes a target and generates a sound pulse that moves out in the surrounding air.

The γ rays in the last octave are X rays generated when an atom explodes.